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ABSTRACT

This manual is designed to assist public health pest control officials in meeting the certification required under the Michigan Pesticide Control Act of 1976. The four sections included describe: (1) Insects of public health significance in Michigan; (2) Other arthropods that affect man; (3) Swimmers' itch parasite and snail host; and (4) Vertebrate pests. Section one discusses how insects affect man. Section two describes how mites, spiders and ticks affect humans. Section four discusses bats, norway rats, house mice, trapping rodents, baits and baiting, types of rodenticides, bird pests, and trapping birds. A list of self-help questions and instructions for completing the questions are presented at the end of each section. (HM)

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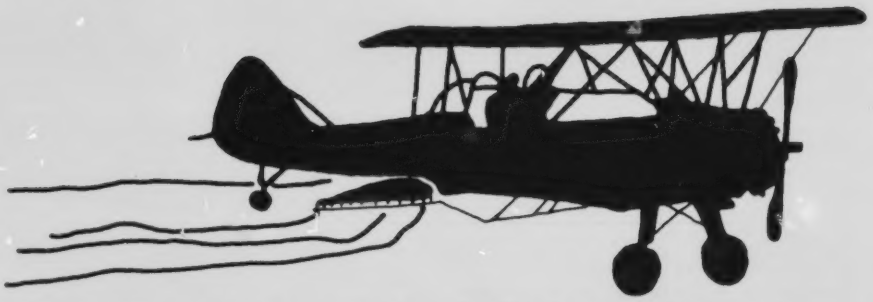
Public Health Pest Control



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MICHIGAN STATE UNIVERSITY

SAFE, EFFECTIVE USE OF PESTICIDES
A MANUAL FOR COMMERCIAL APPLICATORS

SE 024 690

This manual is intended to assist public health pest control officials in meeting the certification required under the Michigan Pesticide Control Act of 1976. Parts of the sections on mite, spider, and mouse control were adapted from "Preparing for Applicator Certification," by Dr. R. E. Heal and are used here under agreement with the publishers, the National Pest Control Association, Inc. The section on bat control was adapted from "Bat Control" Tech Release No. 5-75 of the National Pest Control Association, Inc.

A list of self-help questions and instructions for completing the questions are at the end of each section. If you encounter difficulties in using the manual, please consult your county agricultural extension agent or representative of the Michigan Department of Agriculture for assistance.

Some suggestions on studying the manual are:

1. Find a place and time for study where you will not be disturbed.
2. Read the entire manual through once to understand the scope and form of presentation of the material.
3. Then study one section of the manual at a time. You may want to underline important points in the manual or take written notes as you study the section.
4. Answer, in writing, the self-help questions at the end of each section. Instructions on how to use the self-help questions in your study are included with the questions. These questions are intended to aid you in your study and to help you evaluate your knowledge of the subject. As such, they are an important part of your study.
5. Reread the entire manual once again when you have finished studying all of its nine sections. Review with care any sections that you feel you do not fully understand.

This manual is intended to help you use pesticides effectively and safely when they are needed. We hope that you will review it occasionally to keep the material fresh in your mind.

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INSECTS OF PUBLIC HEALTH SIGNIFICANCE IN MICHIGAN

HOW INSECTS AFFECT MAN

Insects are probably the most successful of all land animals. They are found in the air, on and under soil, and in fresh or brackish water. They eat the leaves and roots of plants and bore into all types of vegetation. Some insects live on or inside other animals, and many compete fiercely with other species as parasites or as predators in preserving the balance in nature. Despite their small size, the combined bulk of insects may equal that of all other land animals. Over 750,000 species of true insects have been described to date, and the number may ultimately reach a million more.

For centuries man has fought insects as pests, as carriers of disease, and as destroyers of his food. This combat will continue for a long time, for he has never eradicated a single insect species from the earth. Today, a number of the most important species are showing increasingly significant resistance to insecticides. However, when the need is urgent and the will is present to do a good job, insects can be kept under reasonable control.

Insects have a long history that stretches back through many geological periods. They appeared in the world long before man, yet insect fossils from coal and amber deposits differ little from their present-day descendants despite a lapse of 250 million years or more. As man emerged and changed, his parasites evolved with him — many of the strictly human parasites such as the body and crab lice having close allies on or in the great apes.

Insects are often thought of as man's most formidable competitors. They despoil his growing plants and stored crops; they greedily suck the blood from his body; they annoy him wherever he goes. The damage that insects do

to growing crops is enormous. They cost the American farmer billions of dollars each year by destroying or decreasing the value of his crops. Flies, fleas, lice and mosquitoes infect man and domesticated animals directly or indirectly with the organisms of many dangerous debilitating diseases.

Transmission of Human Disease

Insect bites or stings are occasionally fatal to humans, but their germ-laden saliva or contaminated bodies may also mark a human victim for death. The most sinister relationship of insects to man and domesticated animals is the part they play as carriers of disease organisms.

Mechanical transmission of disease: Mechanical or passive transmission of disease occurs when the insect transports organisms such as dysentery bacteria on its feet, body hairs, and other surfaces from filth to the human. The house fly, *Musca domestica*, is probably the most loathsome passive transmitter of disease. When in well-housed communities, it is a common sight to see filthy flies crawling over food and utensils and the faces of small children. Scientific studies have shown a close relationship between the incidence of bacillary dysentery and the needless abundance of flies in human habitations. Cockroaches and vinegar gnats are known to visit sewers and liquid excrement, later entering human habitations.

Biological transmission of disease: Disease organisms are ordinarily helpless and inactive, being so delicate that they cannot withstand exposure to sunlight and dry air. These organisms would perish with their victim unless there was some means for them to escape from one host and find sanctuary in another. Diseases are spread in many ways, but insects afford one of the efficient means by which the organisms can infect new hosts. Biological transmission of disease occurs when an insect, mite, or tick is essential in the life cycle of the disease of parasite. The *Anopheles* mosquito, for example, is an essential vector in the spread of malaria. The malaria parasite undergoes a portion of its life cycle in both the insect vector and the human host.

Host-vector relationships: In considering the insect transmission of disease-causing organisms, it is important to understand the relationships between the vector and the host. The malarial parasites, for example. undergo certain stages of their life cycle in the body of the mosquito. This insect is thus an essential host of the disease, in addition to serving as carrier or vector. The parasite undergoes the sexual portion of its life cycle in the mosquito, and thus the insect may be considered as the primary or definitive host. On the other hand, the asexual stages of the malarial parasites are passed in man who therefore is the intermediate host.

Disease transmission is often complicated by the presence of more than one host. Some hosts are not affected by the disease but are able to perpetuate the disease by serving as a safe harborage for the organism. These animals are known as reservoirs of the disease. In some cases it is rather difficult to determine whether an animal is the true reservoir of a disease or is the vector alone. Some ticks and mites are able to transmit disease-causing organisms, such as the rickettsiae causing Rocky Mountain spotted fever, to their offspring and thus serve as both vectors and reservoirs of disease. It is possible in this case that other animals, such as wild rodents and rabbits, are actually the true reservoir.

The relationship between man, the insects, and the microorganisms constitutes a great and only partially solved public health problem. Although malaria and plague have ravaged mankind for thousands of years, the mosquito and the flea vectors were not known until the latter part of the 19th century. Who knows what part insects may play in the transmission of many virus diseases, the host-vector relationships of which are yet to be discovered?

Myiasis means the infestation of man, or animals, by the living maggots of flies. Some forms, such as bot flies, can breed only in this way. The screw worm infests livestock in the South and West and occasionally attacks human beings.

It is a true parasite living only in the flesh of warm-blooded animals. The larvae of some fly species such as the rat-tailed maggots may be swallowed by humans accidentally, producing intestinal upsets.

Poison, Irritation, and Allergy

Many insects, and some spiders, scorpions, and centipedes, have developed poisoning mechanisms to use in self-defense or in paralyzing their prey. Stings and bites may be intensely irritating to humans but seldom cause death. Probably the most dangerous are the bites of the black widow spider, *Latrodectus mactans*, and the sting of a small scorpion, *Centruroides sculpturatus*, found in the Southwest. Even the stings of bees and wasps may prove toxic to persons allergic to their venoms. Insect venom contains complex protein substances or formic acid that may lead to anaphylactic shock or death.

Some insects, such as the puss caterpillar, have urticating hairs rather like those of stinging nettles. Cantharidin present in the blood of certain beetles, such as the blister beetles, causes painful blistering of the skin when the insect is crushed. Mosquitoes, sand flies, fleas, and other pestiferous creatures have done much to destroy man's peace of mind. It is necessary for health workers to understand the control of these pests as heavy infestations may affect the health of people and entire communities.

Entomophobia

Entomophobia means fear of insects. Many household pests do little actual harm but arouse intense feelings of revulsion in susceptible people. Crawling creatures, such as earwigs, bother some people so much that medical attention may be necessary. Feelings of repugnance aroused by infestations of insects must be handled with care by the sanitarian as no reasoning will satisfy affected persons. Some definite action such as spraying an insecticide must be taken to break the chain of circumstances. A moderate feeling of revulsion to insects is of assistance to sanitarians in public health work for it insures the interest of the public in promoting high standards of sanitation.

COCKROACHES

Description

Cockroaches have a broad, flattened shape, six long legs, and long antennae. Adults of most species have well-developed wings. The young resemble the adults except for the lack of wings and their smaller size. Depending on species, roaches are light brown, reddish brown, dark brown, or black; and some have characteristic markings. The species can be distinguished from each other by their appearance and their characteristic habits and habitats. The adults and immature forms of all pest species are present in established infestations.

Life Cycle

The female lays 12 to 48 or more eggs in a capsule which she carries attached to the abdomen until the eggs are ready to hatch or until she deposits the capsule in a safe location. After hatching and emerging from the egg capsule, the nymphs begin scavenging for food, molt several times, and then become adults capable of reproduction. The life cycle may be completed in as little as 40 days for some species and as much as 2 years for others.

Habits and Habitats

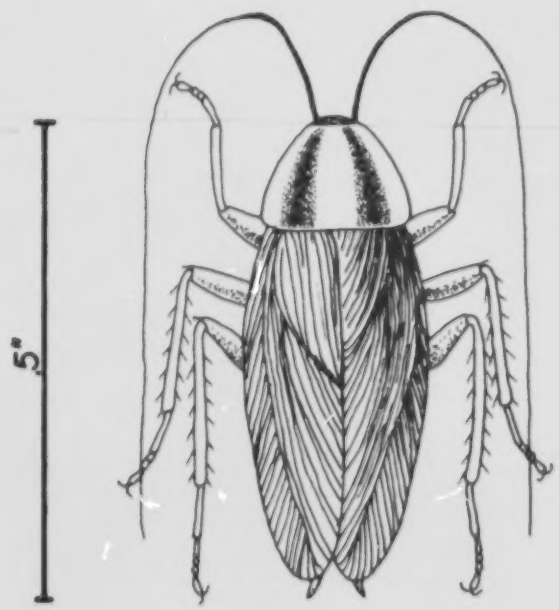
Cockroaches shun bright light, usually hiding all day and emerging at night to forage for food. Their flattened bodies permit them to hide in narrow cracks and crevices. Some species require or prefer moist environments, while other can withstand drier conditions. Roaches gain access to buildings in many ways. Some commonly enter buildings with food supplies while others frequently enter buildings from underground ducts, manholes, and drains leading from sewer lines. Once in the buildings, roaches move freely between floors, rooms, apartments through hallways, hollow walls, plumbing access holes, and almost any route that provides passage room.

Importance of Cockroaches

Although cockroaches have never been proven vectors of disease during epidemics, their association with filth and the fact that they are able to carry the organisms of intestinal diseases on and in their bodies and will deposit these with their excreta on our food make their presence undesirable. There also is an unpleasant odor associated with roaches that is the combined product of their excreta and a fluid regurgitated during feeding. Dishes and liquid foods may retain this odor for long periods and even when no odor is at first noticed, dishes over which roaches have walked may be a source of the odor when filled with warm food. Cockroach species commonly found in buildings do not normally eat clothes, books, and paper products unless their customary foods are unavailable or are insufficient to support the existing populations.

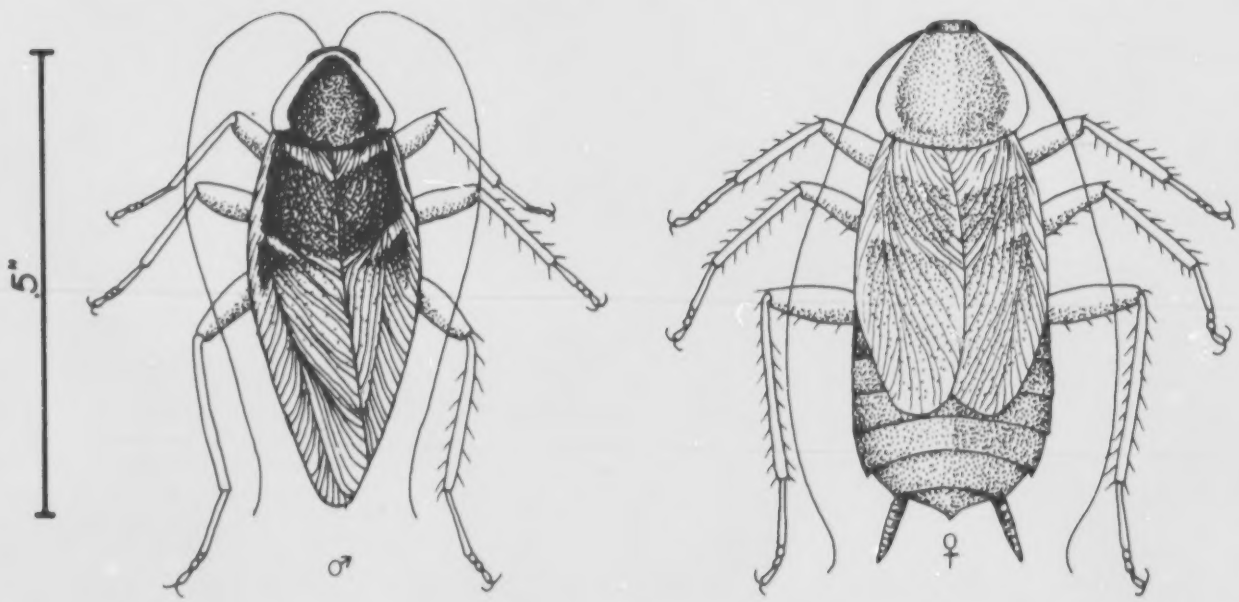
Of the many species of cockroaches that exist throughout the world, only three are numerous enough in Michigan to be of importance. These are the German cockroach, the brown-banded cockroach and the oriental cockroach.

German Cockroach (croton bug), "Blattella germanica"



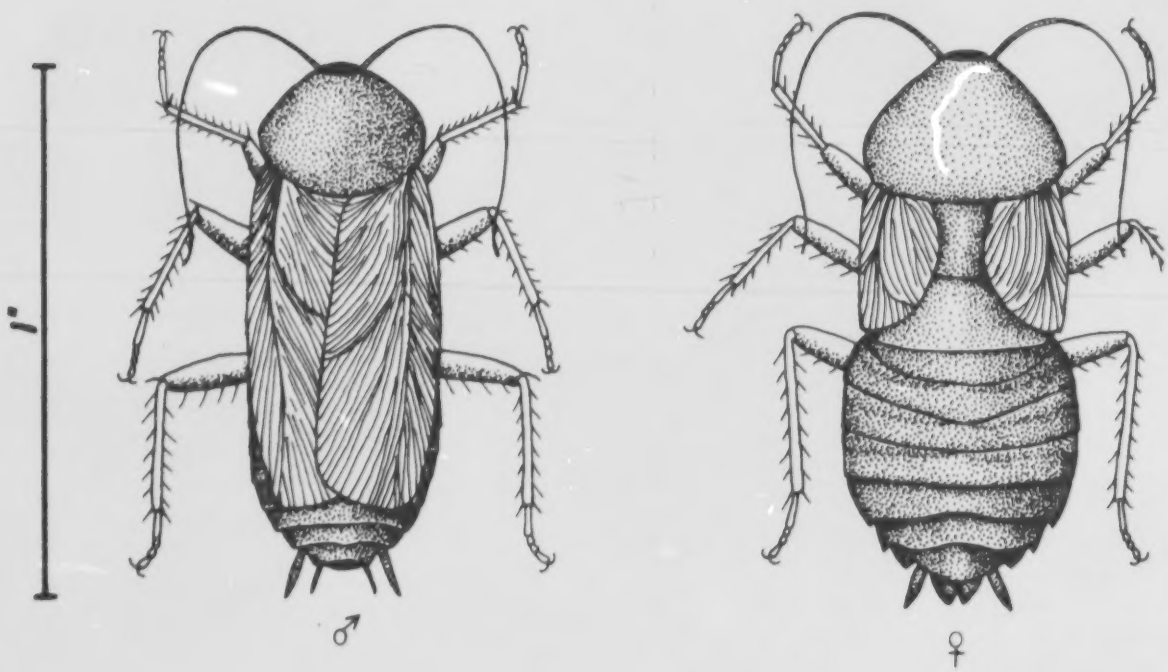
This roach is light brown, with two dark longitudinal stripes on the thorax. Adults are five-eighth inches long and have fully developed wings while the immature stages are smaller and have no wings. The female carries the egg capsule containing from 18 to 50 eggs until shortly before they are ready to hatch at which time they are dropped. The life cycle requires 40 to 60 days. German cockroaches develop and live inside buildings in warm moist areas such as kitchens and bathrooms. Large populations often develop in food-handling areas. They tend to remain hidden in cracks and crevices during the day, and are easily transported in food containers. This species occurs in virtually all parts of the United States.

Brown-Banded Cockroach, "Supella supellectilium"



This roach is light brown, with short, mottled reddish brown wings on the adult female and lighter, longer wings on the male. The wings have two brownish yellow transverse stripes. Adults are one-half inch long while immature stages are smaller and have no wings. The brown-banded cockroach can develop and live in drier locations than can most other roaches. It flies readily and, in contrast to the German roach, is found throughout the buildings it infests. This roach also is widely distributed throughout Michigan and the rest of the United States and because of its ability to develop in a wide variety of indoor habitats, it is harder to control than is the German roach. Egg capsules of this species are smaller than those of the German roach, containing up to 18 eggs, and usually are found attached to various objects rather than being dropped. Females carry capsules for 24 to 36 hours before attaching them to some object. Complete development of this species requires from 95 to 276 days.

Oriental Cockroach, "Blatta orientalis"



This roach is dark brown or black. The female is one to one and one-half inches long, and has only rudimentary wings reduced to mere lobes, while the male is a little shorter, and has fully developed wings which do not reach to the end of the abdomen. Egg capsules contain up to 16 eggs. Females may carry the capsules for several days before depositing them in warm sheltered locations containing suitable food for the nymphs. The full life cycle requires from 311 to 800 days. Oriental cockroaches develop in damp basements and sewers, and most frequently occur in or near basement floor drains and the grease traps and drains of food preparation areas. It commonly occurs throughout the United States.

Detection

Because cockroaches are primarily nocturnal insects, they may be overlooked in routine inspections conducted during daylight hours, but are easily seen at night when lights are turned on in dark rooms. Roaches can be driven from their daytime hiding places by use of pyrethrum aerosols when they would otherwise be difficult to detect.

Control

The control of cockroaches involves both preventive and corrective measures and the specific measures used should be determined by local conditions and the species that are present. Improved sanitation and the elimination or reduction of harborages often will reduce cockroach populations and always will improve the effectiveness and duration of insecticide treatments.

All food materials should be so stored that they are not accessible to cockroaches and garbage and other refuse should be placed in containers with tight-fitting lids. Spilled foods and waste materials should be cleaned up and disposed of at the end of each day before roaches begin their night foraging. All kitchen utensils and equipment should be thoroughly cleaned immediately after use, if possible, or stored where roaches cannot reach them.

The German and brown-banded roaches are usually carried into buildings in food containers or on the undersides of furniture. Careful inspection of materials received will prevent many infestations from becoming established. Most buildings have locations that are adequate to support large roach populations. Typical harborages are found in wall spaces, holes for water pipes and electric lines, electric switch and fuse boxes, spaces behind pictures and wall signs, kitchen drawers and cabinets and other storage areas.

Where food is stored and processed cockroaches congregate under, in, and behind food containers, food preparation areas, food-handling and serving equipment, and dishwashers. Wherever possible, these harborages should be eliminated or made inaccessible to roaches and this normally will result in the population reductions.

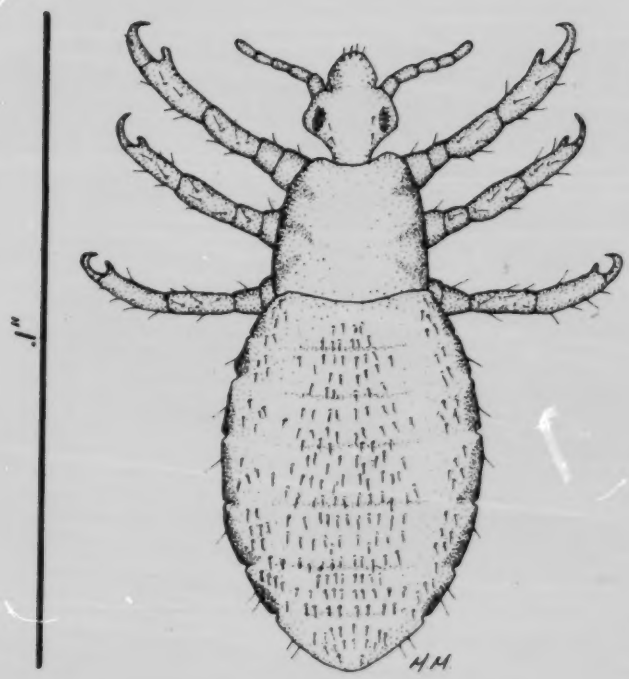
The control of established infestations, however, almost certainly requires the use of chemical insecticides. These should be applied whenever possible to surfaces over which roaches will move at night and to all harborage sites where they remain during the day. The insecticides most commonly used are liquid and dust formulations that are applied as spot treatments. Aerosols also may be used as an adjunct to residual treatments since they are irritants and cause roaches to move from their hiding places and come into contact with the residually treated surfaces. Liquids, either solutions or emulsions, should be used as coarse sprays to wet the surfaces just short of run-off and applied to baseboards, surfaces behind and beneath cabinets, refrigerators, sinks, storage shelves, and interiors of cabinets. The spray treatment should be followed by dust applications to all suspected harborages that cannot be thoroughly treated with the spray. Insecticide dusts should be used in conjunction with liquid sprays wherever possible to treat all sites where liquids may cause fires or electrical shorting. Dusts only should be used in fuse boxes, electrical outlets, stoves, ovens, and heaters. Dust also may be effectively used under buildings, refrigerators, stoves and built-in storage areas. Dishes and other contents of storage areas such as closets and bureau drawers should be removed prior to treatment and not returned until the sprayed areas have dried.

Exposed food should be covered or removed before insecticide treatments are applied. Control of brown-banded cockroaches may require treatment of suspected harborages throughout the building.

It is important that all units of multiple dwellings be treated at the same time to effectively control an infestation in the building, a combination of a dust and spray treatment, thoroughly applied, will give much longer residual control than will the spray alone.

In areas where residual insecticide treatments are not practical (hospital nurseries, etc.), harborage reduction, proper food storage, and suitable insecticide baits are effective in reducing infestations.

HUMAN LICE



Lice have been intimately associated with man for centuries. Infestations with lice occur today in the United States and many other countries despite great efforts to maintain high standards of public health. Public health agencies are often called upon if infestations include or expose large groups of people, particularly those in public institutions such as schools, jails, hospitals, or homes for the aged.

The three sucking lice that infest humans are: the body louse (*Pediculus humanus humanus*), the head louse (*Pediculus humanus capitis*), and the crab louse (*Pthirus pubis*). The body louse is the species involved in epidemics of louse-borne typhus, trench fever, and relapsing fever, but all three cause pediculosis.

Pediculosis (from the generis name of the louse, *Pediculus*) or infestation with lice is generally associated with people living crowded together and having limited facilities for regular bathing and laundering. The condition is most common during times of stress, such as war, and in concentration camps, evacuation centers, labor camps, schools, and institutions. In many countries pediculosis is associated with tramps and migrants and is known as "hobo's disease." Severe infestations lead to scratching, secondary infections, and scarred, hardened, or pigmented skin—the classic signs of pediculosis. After the widespread use of DDT following World War II, there were relatively few reports of pediculosis in the United States. However, as the use of DDT has become restricted, the number of cases of head lice in school children and in people in institutions has been increasing in recent years. Moreover, the growing number of people of both sexes with unkempt long hair and the tendencies in some population groups to live communally, to wear the same clothing for long periods of time, and to bathe irregularly have apparently led to an increase in all three kinds of lice that infest man.

Each of the three human lice cause pediculosis. Head lice are confined to the head hair and scalp where the adult and immature lice, and particularly the eggs, are found fastened to the hairs. Body lice are found on hairy parts of the body below the neck, with adult and immature lice and

eggs frequently on clothing, especially along the seams of the inner surfaces. Crab lice are found in the pubic and anal regions and occasionally in the armpits, on the hairy areas of the chest, and on the eyebrows and eyelashes. Lice are transmitted from an infested person to another by direct contact and indirectly by contact with personal belongings, especially combs, clothing, headgear, and bedding. Animal lice normally do not infest man.

Head lice are often the cause of pediculosis outbreaks among persons in schools, jails, hospitals, nursing homes, and summer camps. Adult and immature head lice are seen less frequently than the eggs (commonly called ("nits") which are fastened to the hairs, particularly those behind the ears. Public health workers should be aware that foreign material in the hair and hair casts have been mistaken for eggs. A hair cast is the inner hair root sheath which has slid along the hair shaft. A number of cases of pseudopediculosis have been reported in which solidified globules of hair spray were confused with eggs.

In Oregon, several thousand children and adults were sent home from school because many had small, whitish objects attached to their hair. An amorphous cellular mass was found in some cases and hair follicle mites (*Demodix sp.*) in others. However, only a very few of these persons were found with head infestations of lice. The louse egg seen through a microscope is easily distinguished from other objects by distinct characteristics: the ring at the base of the egg by which it is fastened securely to the hair; the egg itself, frequently with an embryo visible inside; and the cap (operculum) with definite pores.

When outbreaks occur in schools, the school child must be treated daily upon returning home. Otherwise the child is likely to become reinfested and the condition may spread to his classmates. In many instances other family members and close associates may require treatment.

Public institutions, such as hospitals, jails, and nursing homes, sometimes find incoming people infested with lice. If the incidence is high, it may be necessary to use experienced inspectors or public health nurses to inspect all people entering such institutions and to treat infested persons.

Cases of infestation must be handled as a medical problem and considerable effort must be made to avoid exposure of patients to ridicule.

Sucking lice belong to the order Anoplura. These wingless insects are flattened dorsoventrally, i.e., from top to bottom like a pancake. Adult lice have mouthparts consisting of stylets modified for piercing and sucking; the stylets are retracted within the head when not in use. Their legs are short and stout, with a large claw on one or more of the three pairs of legs for grasping and holding onto hairs. The eggs of lice differ from those of most other insects because they are attached by cement and possess a distinct cap, or operculum. Lice have three immature (nymphal) stages which resemble the adult stage. Most nymphs differ from adults in having fewer hairs on their bodies, fewer sclerotized plates, and in being sexually undifferentiated. Lice are, therefore, good examples of insects with incomplete or gradual metamorphosis, that is, insects with three stages of life: eggs, nymphs, and adults. Females are usually larger than males and the tip of their abdomen is notched or bilobed. Males have the tip of the abdomen rounded with the somewhat cigar-shaped genitalia often visible through the body wall.

Most sucking lice spend their entire life as ectoparasites on mammals. The body louse is a conspicuous and important exception because it rests on clothing except when feeding. Sucking lice occur only on mammals, never on birds, reptiles, or amphibia. Each species of louse generally feeds upon only one species of host animal, one genus or, more rarely, one group of mammals. In general, closely related groups of mammals appear to be infested by closely related species of lice.

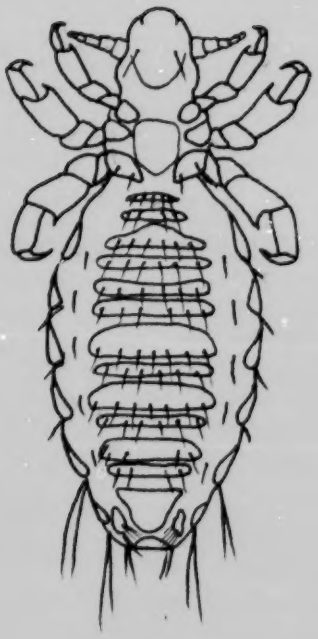
Pediculus humanus occurs in two different forms often designated as distinct subspecies: *Pediculus humanus humanus* (the body louse) and *Pediculus humanus capitis* (the head louse). *P. humanus humanus* is called *P. humanus corporis* or *P. humanus vestimenti* by some taxonomists. These two forms differ morphologically in size, proportion, and color, but there is an overlapping of characteristics in the extremes of any series. Therefore, it is impossible to assign an individual specimen to either racial form with certainty, although

series usually can be determined with some certainty. In general, body lice are 10 to 20 percent larger than head lice and are often lighter colored, particularly those body lice from dark-haired Caucasians or Orientals. In addition, body lice tend to have more slender antennae, less pronounced constrictions between the abdominal segments, and more developed musculature of the abdomen.

The two forms are similar physiologically, but laboratory experiments indicate that the body louse is more efficient because it lays more eggs, lives longer, and is more resistant to starvation. Biologically, the chief differences are in the habits, one form living on the head and neck and the other on the body. Correlated with these two habits are differences in egg laying, i.e., the head louse cements her eggs to the hairs of the scalp, while the body louse normally glues her eggs to fibers of clothing or, less commonly, to body hairs. Mating will occur between head and body lice; it has even been reported that typical head lice confined on the body lose their subspecific characteristics and acquire the morphological characters of body lice after four or more generations.

From the public health viewpoint, the important difference between the two forms is that the major epidemics of typhus have all been associated with widespread infestations with body lice, not head lice. Furthermore, typhus remains endemic in cool areas where people wear several layers of clothing and body louse infestations are common. Typhus is rare in tropical areas such as Malaya or tropical Africa where little clothing is worn, and most specimens found are head lice.

Head and Body Lice



The egg: The large, yellowish egg of *Pediculus humanus* is about 0.8 mm. long by 0.3 mm. broad. It is provided with a cap at one end to admit air during development of the embryo and to facilitate escape of the young insect. The egg of the head louse is attached to a human hair with cement (Figure 2). The egg of the body louse is cemented to fibers of the underclothing. The eggs on the human scalp or undergarment are incubated by heat from the body and hatch in about a week. Hatching of eggs is greatly reduced or completely prevented by exposure to temperatures about 100°F. or

lower than 75°F. Thus, the body louse is readily controlled when the same articles of apparel are worn intermittently. When the same clothing is worn for several weeks or months, it may become heavily infested with body lice. Conversely, if clothing were stored for a month, even without treatment, all eggs would hatch or die, and any young which hatch would die.

The nymph: After emerging from the egg, the louse nymph molts three times before becoming a sexually mature adult. Therefore, there are three nymphal instars, differing from each other by the increased length of the abdomen as development progresses. The nymphal stages require 8 to 9 days for lice remaining in contact with the human body, but may require 2 to 4 weeks when the clothing is removed at night. If the clothes are not worn for several days, all of the lice will usually succumb. The total life cycle of head and body lice may be completed in about 18 days.

The adult: The adult body or head louse differs little from the nymph except in size and sexual maturity. The elongate body has three parts: a head, a fused thorax, and a segmented abdomen over three-fifths the body length. The male is smaller than the female. Table 1 lists some of the morphological characteristics of human lice.

TABLE 1. MORPHOLOGY OF LICE PARASITIC ON MAN

	Body Louse	Head Louse	Crab Louse
Size of Adults			
male	2.0 - 3.0 mm.	1.0 - 1.5 mm.	0.8 - 1.0 mm.
female	2.0 - 4.0 mm.	1.8 - 2.0 mm.	1.0 - 1.2 mm.
Abdomen	Elongate, without hairy lateral processes	Elongate, without hairy lateral processes	Short, with hairy lateral processes
Legs	Approximately equal	Approximately equal	First pair smaller, more slender than 2nd or 3rd pairs
Color	Grayish-white	Grayish-white with dark margins	Grayish-white

The head bears a pair of eyes, mouthparts, and a pair of short, four-segmented antennae. The mouth is encircled by six pairs of hooks by which the louse attached to the skin during feeding. There is also a retractable, soft, haustellum with piercing stylets to open the wound and provide a salivary duct.

When ready to feed, the louse anchors its mouth to the skin, stabs an opening through the skin, pours saliva into the wound, and pumps blood from the injury into the digestive system by means of the pharyngeal pump.

The three thoracic segments each bear a pair of strong, five-segmented legs. Each leg terminates in a hooklike claw which by opposing a thumblike tibial process enables the louse to maintain its hold on hairs and fibers. The abdomen is elliptical and has nine segments. Mating occurs frequently and at any time in the adult's life, from the first 10 hours to senescence. Eggs are laid 24 to 48 hours later, depending upon temperature conditions. Eggs are cemented on head hairs by head lice or on the underclothing by body lice. If the human is relatively nude, as in some tropical areas, lice may infest beads and necklaces. Body lice may deposit 9 or 10 eggs per day and total of 270 to 300 eggs in a lifetime. Head lice are less prolific, depositing about four eggs per day for a total of about 88 in a lifetime.

Human lice depend upon human blood for sustenance. They suck blood for long periods of time, but do not ordinarily become engorged. Some individual lice feed two avidly, causing rupture of their digestive system, and succumb because of their greed. During feeding, dark red feces may be deposited on the skin.

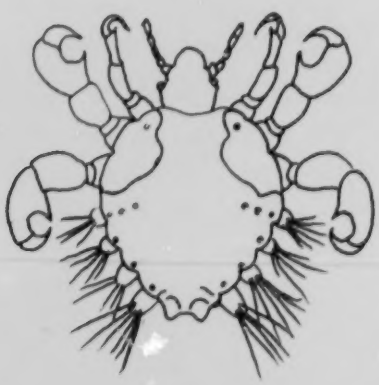
Adults and nymphs of head lice are found in the hair and on the scalp; they tend to be most prevalent on the back of the neck and behind the ears. They are not known to infest eyebrows or eyelashes, but the crab louse may.

As many as 1,000 body lice have been removed from the undergarments of one person. It is more typical to find less than 10 lice per person. Most of the lice are on the inner surface of the clothing, next to the skin. Females

tend to congregate along seams for egg laying. Some of the adults tend to migrate away from the skin to the outer garments, hence to other persons. Head and body lice can move fairly rapidly and will pass from host to host, or from one host to bedding, by simple contact.

It is difficult to find human lice and crab lice away from man. Beds occupied every night by insanitary individuals have more chance of being lousy. If unoccupied for several nights, they tend to be free of lice. Head and body lice may be acquired by personal contact and by putting on infested garments. Head lice may be acquired by contact with upholstered chairs and by using infested brushed and combs. Hairs with eggs attached may be blown about. Lice tend to leave a feverish patient and seek other hosts.

Crab lice



Crab lice (*Pthirus pubis*) are small grayish-white insects with a short abdomen bearing hairy lateral tufts and large second and third pairs of legs which gives them a crablike appearance (Figure 3). The scientific name of this insect is often incorrectly spelled Phthirus pubis or Phthirius pubis.

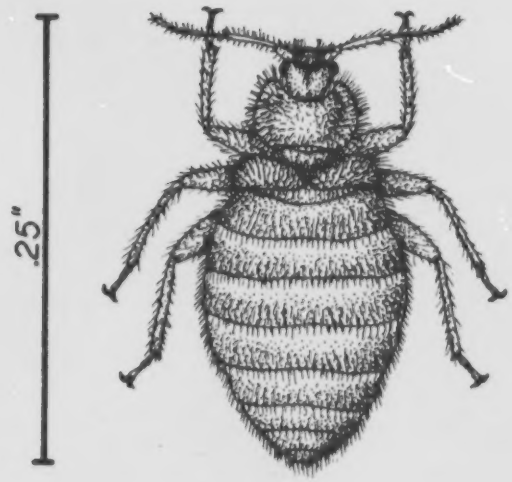
Relatively few details of the biology of the crab louse are known because they are difficult and unpleasant to rear in captivity. These insects are most commonly found on hairs in the pubic areas, but they may be found on hairy areas of the chest or airmpits. Infestations of the eyebrows and eyelashes have been reported frequently. Crab lice on the eyebrows feed in a very localized area and cause hemorrhages into the skin which result in a bluish pigment directly above the eyebrows. Quarantine doctors often note this bluish coloration as one of the first signs of louse infestations.

The life cycle of the crab louse is similar to that of head and body lice. The eggs are glued to hairs but are smaller and have a more convex cap than do *Pediculus*. It is not known definitely how many eggs are laid in nature, but one female confined under a stocking laid 26 eggs, averaging three per day. There are three nymphal stages. In a few specimens that were carefully studied, it took 13 to 17 days for them to become adults. Adult life apparently lasts less than a month. All stages are more sedentary than those of head or body lice. They tend to settle down at one spot, grasping hairs with the legs of both sides of the body, inserting the mouthparts, and taking blood intermittently for many hours at a time. The legs are adapted for grasping rather large hairs and, in the position adopted, the adult prefers hairs rather widely spaced (compared with the dense hairs of the head). This may partly explain the distribution of the crab louse which is found most commonly on the hair in the pubic and anal areas. This insect survives only a short time away from the host; 200 crab lice were removed from a man and only one was alive less than 24 hours later, although the insects were kept in moist air.

Crab lice are spread chiefly by sexual contact, but may be acquired by other means such as infested toilet seats and beds, and by close personal contact. Many authorities believe that there has been a genuine resurgence in the number of cases of crab louse infestations, related to the present worldwide climate of cultural permissiveness. "It is not surprising that the incidence of *P. pubis*, like that of other venereal diseases, has risen significantly as the

boundaries of sexual freedom have blurred." Small children may become infested with crab lice on their eyebrows or eyelashes from their mothers or nurses or through normal play activities. "As many as 100 have been counted on the eyelashes of a single person; in this site they may induce blepharitis," an inflammation of the eyelid.

BEDBUGS AND BATBUGS



The bedbug, *Cimex lectularius*, has been prevalent in Europe for centuries and in this country since early colonial days although apparently unknown to the American Indian. The adult is one-fifth inches long, one-eighth inch wide, and reddish brown in color. The flattened oval body is adapted for hiding in narrow crevices. The head bears a pair of four-segmented antennae and piercing-sucking mouthparts which fold to lie between the first pair of legs. The wings

are represented by pads. The body may become greatly enlarged and blood red in color during the taking of a blood meal. From 1 to 5 eggs are laid per day over a period of 2 to 10 months until approximately 200 are deposited. The eggs are cemented to bedding or in cracks. Development from the egg through a series of nymphs to the adult takes 18 to 56 days, and the adults normally live 6 months to a year. A blood meal must be taken before each molt. The famale may live nearly a year without food and can endure freezing temperatures for considerable time.

Bedbugs are found on the clothing and possessions of infested individuals. They may be found on poultry and may be abundant in farmer's markets. A heavily infested house has a distinctive odor. Some people are very sensitive to bedbug bites while others are hardly aware of them. Immediately after feeding the bedbug defecates, passing out the semisolid sticky remains of the last meal. The material may enter the bite injury, but as yet the insect has not been incriminated in the transmission of any communicable disease. Bedbugs may cause nervous disorders in sensitive people, and may contribute to the ill health of both children and adults. Man is the preferred host, but bedbugs will feed readily on poultry, mice, rats, and other animals.

To Control Bedbugs

1. Calk or otherwise repair all cracks and spaces behind baseboards and other areas of the house. Wood paneling and loose wall paper of all kinds make an ideal hiding place for bedbugs.
2. Treat infested areas with an insecticide liquid or dust registered for this purpose. When using one of these insecticides:
   a. Thoroughly spray baseboards, closets, wood paneling, and other places that harbor bedbugs. Apply a heavy film of insecticide to board surfaces and into cracks, but avoid spray runoff because of the mess it may make.

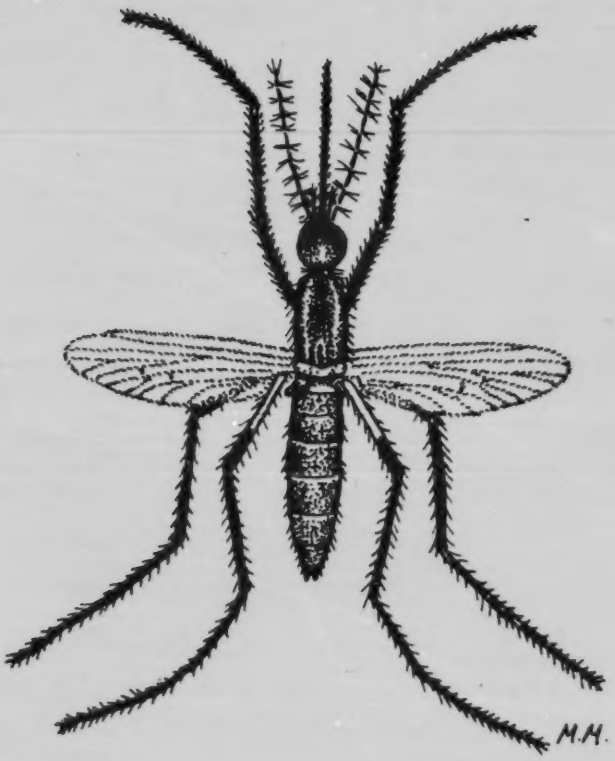
b. Thoroughly treat the frame, slats and springs of beds. To treat the mattress, apply a light mist to seams, tufts, and folds, but not to the entire mattress. Allow four hours for the spray to dry before covering it with a sheet. Ventilate the room while spraying and during the drying.

c. Treat the upholstered furniture in the same way as mattresses—that is, lightly spray or dust only the edges and seams of cushions, and the inside (hidden) framework. Avoid treating sit-on or arm rest areas. Do not use sofas, etc., until they are thoroughly dry; or better still, do not use them until 72 hours after treating with an insecticide. Before allowing children on treated furniture, vacuum clean it thoroughly to remove loose and excessive amounts of chemical.

Batbugs can be distinguished from bedbugs by the longer hairs on their body. They are associated with bat infestations in buildings and are known to attack man.

Control of batbugs involves the elimination of bats from the building and the application of a residual insecticide for the elimination of batbugs and other anthropods.

MOSQUITOES



Mosquitoes are undoubtedly the most bothersome insect pests found in Michigan. Over 50 different species of mosquitoes are known to be present in Michigan, and individual feeding habits and seasonal abundance of these species assure the presence of mosquito problems throughout Michigan during nearly all of the months of spring, summer and fall.

Mosquito species vary greatly in flight range habits and capabilities, biting preferences, abundance, and type of habitat most suitable for their development. All species have four distinct stages in their life cycle and the immature stages of every species develop only in water. An adult female mosquito may lay up to several hundred eggs during her lifetime. The location selected for depositing these eggs varies with species. Those deposited directly on water surfaces usually hatch within a short period of time, but eggs deposited on damp or even dry soil, in depressions subject to periodic flooding, may survive for prolonged periods. The eggs of some species, including some of the most common mosquitoes in Michigan, can remain viable up to a year or more on moist or dry soil before they are flooded and hatch.

The larvae, often called wrigglers, emerge from the eggs and feed upon minute forms of animal and plant life and decaying organic matter in the water.

When fully grown, they develop into pupae. The pupal stage of the mosquito, also called a tumbler, involves a transition from the aquatic form to the adult. When this transition is completed, the pupal skin splits along the upper surface, and the adult pulls itself up and out of the floating skin—on which it rests until ready to fly. Development time from egg to adult varies with temperature, and may be as short as 7 to 10 days in midsummer.

Only the female mosquito sucks blood, using this nutrient for development of eggs. Feeding preferences of adult females and distances they may fly to obtain a blood meal are usually quite specific for a given species, but vary widely between species. Some species feed only on birds, some on wild game, and others on domestic animals and man. Certain species may fly many miles from their larval habitat while others rarely go beyond a half mile. A number of species found in Michigan are such fierce biters, and appear in such large numbers, that they make some areas nearly uninhabitable. They can even pose a threat to the existence of some wildlife during the warmer times of the year.

Mosquitoes create both direct and indirect human health hazards. Most obvious are loss of sleep due to night-biting mosquitoes, irritation from bites, and secondary infections from scratching bites. Reduced efficiency of workers is a less obvious, but important, consequence of large numbers of biting mosquitoes. At least four mosquito-transmitted diseases—dog heartworm and the California, St. Louis and Eastern equine forms—occur in Michigan and adjacent states. These are normally animal diseases, but can be transmitted to humans. So mosquito control is a matter of both comfort and health protection.

Mosquito Control

Mosquito control operations may be directed against the larval or adult stage of the insect, or both. However, the most satisfactory and long-lasting control of mosquitoes is accomplished by eliminating or modifying existing water

accumulations so they are not suitable for mosquito larvae. These permanent control operations normally are beyond the capabilities and resources of individuals or commercial controllers and require governmental participation. Commercial pest control operators are most often involved in mosquito control in areas where no community control program has been established or where existing programs are inadequate.

Temporary Larval Control

Insecticides used to control mosquito larvae are called larvicides and the degree of control obtained with larvicide applications often depends upon the degree of water pollution and the type and amount of vegetation cover present. If cover is heavy or organic matter in the water excessive, it may be necessary to increase the concentration of volume of the insecticide used. Granular insecticide formulations may be required to treat water accumulations covered with dense shrubbery, grass or other types of emergent vegetation since liquid formulations are deposited on the surfaces of the plant cover and do not reach the larvae present in the water. Water in containers that cannot be drained or removed from the area should also be treated with larvicide. Frequency of larvicide application varies considerably with temperature and mosquito species, but must be often enough to prevent larvae from developing into adults. Applications each 10 to 14 days are normally adequate for Michigan summer conditions. All potential larval breeding sites within adult flight range of the controlled area must be treated if satisfactory control is to be achieved.

No larval control operations should be alternated until it has been determined that the water to be treated does contain mosquito larvae and pupae, and that they are species that actually bite humans.

Temporary Outdoor Adult Control

Insecticide mists or fogs are most commonly used to reduce adult mosquito populations to an acceptable level in outdoor areas. Both fogs and mists are applied as space treatments that depend primarily upon the wind for distribution. Neither mists nor fogs should be applied in winds of more than five

miles per hour. Optimum windspeed is two to three m.p.h. in open areas and slightly higher in forested areas. For best results, air temperature near the ground must be cooler than at six feet or more above the ground. This condition, called a thermal inversion, assures that insecticide particles will stay close to the ground where most flying and resting mosquitoes occur. Thermal inversion occurs naturally from late evening until sunrise, so the most effective fogging and misting operations are conducted at night.

Fogs applied during the heat of the day nearly always rise rapidly, disperse in the air, and are totally ineffective in controlling mosquitoes. The effectiveness of mists is also greatly reduced when used during the day. Insecticide fogs have no lasting effect so they must be re-applied whenever the number of mosquitoes increases beyond the "level of acceptance." Mists may provide a slight residual action but their primary effectiveness results from direct contact with mosquitoes. Mists may be applied under a wider variety of atmospheric conditions than fogs, but have the disadvantage of poorer penetration of vegetation. When oil base insecticide formulations are applied as mists, they may burn foliage or produce objectionable residues on laundry, automobile paint and windows unless care is exercised in the operation of the misting machine.

Persistent insecticides formerly available in Michigan (DDT and related chlorinated hydrocarbons) provided effective adult mosquito control when applied as a residual spray to vegetation in a belt at least 20 feet wide, surrounding the areas to be protected. However, insecticides now approved for use in Michigan usually will not persist long enough to provide satisfactory control when used in this way. When applied as residual sprays to protected areas on the outside of buildings, cabins, sheds and other locations not exposed to rain or dew, presently approved insecticides may be used to supplement other control methods. When applied only as residual sprays, these insecticides usually will not reduce the number of adult mosquitoes to an acceptable level.

Temporary Indoor Adult Control

Aerosol space sprays are recommended for immediate indoor control. This type of spray is usually more efficient if treated area is kept closed for at

least 15 minutes following treatment. Resin strips impregnated with insecticide may also help to control adult mosquitoes indoors, but are effective only if the space is enclosed and there is minimal air exchange. This type of control should not be used in food preparation and serving areas, nurseries or facilities in which infants, aged or ill people may be exposed to the vapors.

BITING FLIES

Blackflies

Blackflies, sometimes called "buffalo gnats," are small black or gray flies with stout humpback bodies, short, broad wings and short legs. They feed on the blood of wild or domestic animals, and birds. In some parts of Michigan, they are particularly vicious pests of humans. The blackfly season is longer than that of most other blood-sucking flies. The first adults appear late in April, reach their biggest numbers in May and June, but persist in diminishing numbers until late October.

In some areas of Michigan, blackflies become so numerous that it is nearly impossible to remain out of doors. Blood loss from their bites has resulted in death of both domestic and wild animals. If the blackfly is not seen while biting, its bite is readily recognized. There is no pain while the fly punctures the skin and feeds, but the site of the puncture is usually marked by a small trickle of blood which appears after the fly has finished feeding. Within an hour, the area around the bite swells and an intense itching begins that may last for several days. Some individuals become sensitized to blackfly bites and also suffer pain and severe swelling in the area of the bite. Occasionally, there are additional reactions or extreme swelling requiring hospitalization.

Unlike mosquitoes, blackflies bite only during the day. When feeding on animals, they crawl through the hair or feathers to the skin, or enter the ears and nostrils to bite. On man, they usually feed on exposed skin, but may crawl through openings in the clothing to bite covered parts of the body.

Blackflies lay their eggs in a variety of places, but all are either in running water or its immediate vicinity. One female may deposit as many as 500 eggs in one egg-laying period—usually in masses on stones, vegetation or other partly submerged objects at or near water surfaces where they are immersed or continually wetted. Eggs hatch in 4 to 12 days and larvae attach themselves to stones or plants in the stream with a small suction disc and fine silken threads. The larva transforms to a pupa and is firmly attached within a silk pupal case spun by the larva just before pupation. Duration of the aquatic stages varies from two to three weeks to several months, depending upon species, temperature and other conditions.

Upon emerging from the pupal skin, the flies take flight immediately and may live from a few days to several weeks. While some species have only one generation each year, others have two or more. In general, southern Michigan species have multiple generations each year. Generations of the various species overlap so that all stages of blackflies may be present in a given area most of the summer. Some species overwinter as eggs and others as larvae. There is little precise information concerning the flight range of adults, but one prairie species in Canada has reportedly attaked livestock as far away as 100 miles from its source. The most common species in Michigan are not likely to fly this far, but still have relatively long flight ranges.

DDT provided the most effective blackfly larvae control ever formulated, but its use has been restricted in Michigan, and there is no alternate insecticide that produces the same effective larval control. Outdoor space sprays recommended for adult mosquito control offer some local temporary relief from blackflies. Probably the most effective way to prevent blackfly bites is to apply insect repellent to exposed skin areas and keep clothing tighly fastened.

Stable Flies

The stable fly is often known as the biting housefly because of its close resemblance to the housefly. The major difference between the two is the

sharp "beak" of the stable fly which is used to pierce human or animal skin and suck blood. Unlike most other biting flies, both male and female stable flies feed on blood. They are often annoying summer pests at many of Michigan's beaches and recreation areas.

Females lay their eggs in moist, rotting organic matter, such as lawn clippings, straw and grain wastes or piles of aquatic vegetation that accumulate along the shores of lakes. Development from egg to adult may occur in just two weeks in the hottest days of the summer, but three to four weeks is more common. Adults live up to 60 days or more, and take blood meals several times daily throughout their lifetime. Stable flies usually remain outdoors but will enter animal quarters, houses and cabins, especially during cloudy and stormy summer weather.

The most effective method for controlling stable flies, like most other biting insects, is removal of favorable breeding sites. Suitable breeding sites can usually be eliminated within developed recreational areas, but it is rarely practical to remove all of the numerous and widespread sites present near most Michigan recreation areas. Removal or drying (by spreading out) of accumulations of rotting vegetation within and adjacent to the recreation area will reduce the pests' numbers, but its long flight range makes it difficult to completely eliminate. Periodic removal of aquatic vegetation deposits on beaches and lakeshores will also help control stable flies. Indoor space sprays or aerosols, such as those used against mosquitoes, will eradicate stable flies that enter animal shelters or human habitations. Skin or clothing applications of insect repellents containing diethyltoluamide (Deet) provide protection from stable flies. There are no known effective insecticide control measures that are practical for large area treatments.

Horseflies and Deerflies

A number of species in this group of flies are very common in Michigan and are bothersome pests in many low, moist, recreational areas. Large

members of this group are commonly called horse or moose flies. These include a number of very large species, some with a wingspan exceeding two inches. Smaller species are called deerflies. Both horseflies and deerflies are strong fliers and commonly have brilliantly colored eyes that are banded, spotted or striped with green or purple. Only the females suck blood. They normally attack other animals more readily than man, but can also be very bothersome to humans. These biting flies are most abundant in swampy, forested localities, and frequently occur in large numbers in recreational areas located near extensive marshes. Adults are most active on warm, sunny days and are normally present in Michigan from late May until September.

Female horseflies and deerflies lay their eggs in compact masses of several hundred on the leaves of aquatic plants or vegetation bordering pools, swamps or other bodies of water. Eggs hatch in about one week and the immature larvae drop into the water or damp soil where they spend one to three years completing their development to the pupal stage. Adults emerge from the pupal case in two to three weeks.

No satisfactory control for this group of biting flies has yet been developed. Their extensive breeding grounds and location of the larvae in water or moist soil makes it impractical to attempt treatment with chemical insecticides. Drainage of breeding areas is generally impractical. Suitable clothing and an application of insect repellent containing diethyltoluamide (Deet) to areas of exposed skin will provide adequate protection from their bites.

Biting Midges

This group of biting flies includes several types of very tiny insects known as "punkies," "sandflies" and "no-see'ums." Those that feed on humans bite mainly in the evening and very early morning. The burning and irritation they cause is far greater than would be expected from an insect of this small size.

Again, elimination of suitable breeding sites is the most effective method for control of these pests. Location of these areas, however, is an extremely

long and tedious task, even for a trained expert. Biting midges usually develop in the bottom mud of ponds, marshes and swamps or other similar wet soils, which are rich in organic material. The minute size of the larvae makes it extremely difficult to loçate their breeding sites. If breeding areas can be located, drainage, diking or deepening the margins of ponds and streams may provide effective control

Due to the limited flight range of the adults, these flies can be easily controlled in localized areas with the same insecticide mists or fogs used for adult mosquito control. Biting midges are weak fliers and are greatly inhibited by even moderate to light winds. Keep grassed areas closely mowed, shrubbery and low vegetation away from human and animal habitations, and thin trees and shrubs to encourage stronger wind currents.

Biting midges are also attracted to lights. Their tiny size enables them to enter tents, cabins and cottages through average mesh screen. Indoors, an aerosol containing either pyrethrum (pyrethrins) or allethrin is effective. Fortunately, the weak flying ability of this group of insects restricts their nuisance to very limited and localized areas.

NONBITING FLIES

Several species of nonbiting flies which may affect health, cause discomfort and are annoying to man are discussed in this section. Although they differ in appearance, all are in the order Diptera and have complete metamorphosis (egg, larval, pupal and adult stages).

The housefly, "Musca domestica"

The housefly is known in all of the areas of the world, and is the most widely distributed insect of importance to mankind. In some areas, it may constitute 98 percent of all flies entering houses. As a matter of necessity, a large part of any pest control program will be directed against house flies.

In general, the housefly is gray in color. The gray thorax is marked with four equally broad dark stripes running longitudinally. The mouth parts are padlike and are adapted for taking up liquified foods. They may be partly withdrawn into the head capsule when not in use. Eggs are laid and larvae develop in animal and vegetable refuse. Garbage contents of pit privies, animal manure, spilled animal feed, and soil contaminated with organic matter such as from washings of any of those items are favorite breeding places. Houseflies are very prolific, each female laying several masses of many eggs. Under favorable conditions the eggs hatch in 24 hours or less. The maggots, which are creamy white and about one-half inch long when mature, move about in the breeding medium to secure optimum temperature and moisture conditions. The larval stage lasts 3 to 24 days; the usual time in warm weather is 4 to 7 days. Full grown larvae move to dry parts of the breeding medium or move out of it into the soil or sheltered areas under debris to pupate. The pupal stage usually lasts 4 or 5 days; under very warm conditions only 3 days may be required, and in cold weather, flies may remain in the pupal case for several weeks. When this stage is completed, the adult pushes open the end of the pupal case, works its way to the surface of the ground, and after drying and hardening, flies away to feed. Mating may take place a day or two following emergence from the pupal case.

Many of the enteric diseases of man are transmitted by the housefly. Included in these diseases are the dysenteries, cholera, and typhoid fever. The fly simply transports the organisms causing these diseases from man's feces to his food. Sometimes these organisms are carried on the flies' feet or body hairs, and frequently they are regurgitated onto the food when the fly attempts to liquify it for ingestion. Because the housefly has a wide flight range and varied food tastes, and because the female is naturally attracted to collections of filth in which to lay her eggs, the presence of flies is dangerous.

There is no substitution for sanitation in housefly control. With the problems of insecticide resistance becoming more widespread and complex, appropriate action to assure good sanitation practices is essential if good fly

control is to be achieved. Proper disposal of food wastes is essential to prevent attraction of flies to food service areas and to prevent breeding at those locations. These wastes include all garbage and such liquids as wash water. Garbage should be placed in cans with close-fitting lids. Cans should be kept on racks, and should be washed frequently. Care must be exercised where repeated washing of cans occurs not to let the water run onto the ground or gravelled areas. Refuse collection containers which receive garbage, tin cans and other discarded food packaging material, or other items which attract flies or contribute to breeding media, should be placed on racks. Cans should be washed, with hot water and detergent. Garbage should be picked up at twice weekly intervals and disposed of in properly operated sanitary landfills. Chemical treatment of breeding areas hastens development of resistance to insecticides more than does chemical control measures for adults. Therefore, emphasis should be placed on sanitation, supplemented by larviciding only as an emergency measure.

To keep flies out of buildings, screen all doors and windows with 16 or 17 mesh screen. Use automatic closers on all outside doors and keep them properly adjusted.

Fly traps will catch live houseflies and are especially effective when there are large numbers. Place them out of the wind and on the sunny side of the building (except in hot weather when a south exposure is not the best).

An electric grid placed in the open will aid in control. Specifications vary, but a grid made of parallel wires spaced one-quarter inch apart and having a high voltage, low amperage circuit is ample for houseflies.

The application of insecticides for the control of adult flies indoors usually includes the use of aerosols. Application of insecticides with some residual action may also be effective if applied around windows or other areas visited by flies. Vapors with insecticidal action emitted by impregnated resin strips may offer some control of adult flies but care must be taken not to place these strips in areas prohibited on the label.

For control of adult flies out of doors, aerosols applied by mist, fog, or ultra-low-volume equipment is of value. Fly baits may offer some control in certain situations. Residual sprays may be used around areas of high fly concentration such as garbage cans. Resin strips impregnated with insecticide are effective if placed inside garbage cans or bulk solid waste containers.

Biological control of houseflies involving the release of sterile flies into the population or the use of parasites or predators is not at this time of any practical value.

Blow Flies

Blow flies may be identified by their relatively large size and shiny blue, green, or black abdomens. Various species of these flies breed in animal carcases, meat scraps, and decaying vegetable matter. Adults are strong fliers and are attracted to oviposition sites from long distances. The life cycle is similar to that of the housefly.

While these flies have essentially the same potential for mechanically transmitting disease organisms as do houseflies, they have fewer opportunities because they are less inclined to enter buildings. The immature stages have been found often in wounds of man and other animals, and many of the flies in this group are relatively important in causing myiasis in man.

Occasionally blow flies cause annoyance indoors in much the same way as do house and cluster flies. They are larger and more robust than houseflies. Their abdomens are either blue or green, or in some cases, violet or copper. They fly with a buzzing sound.

Blow fly maggots develop in protein-type materials such as cheese, eggs, meat, fish, dead animals and droppings of dogs and other animals. Different types of organic matter often encourage the presence of different species of flies. In certain neighborhoods it is not uncommon to find blow flies associated with dog manure.

Normally blow flies originate outdoors, but infestations can arise from dead rodents and birds inside houses, or even from maggot breeding places in birds' nests in eaves troughs or above windows, or even in soiled carpets and rugs.

Destroy all sources of maggot infestation. Bury excrement of dogs each week and spray pens with a suitable insecticide.

Keep screens on windows and storm doors. Use automatic closers on all outside doors.

Dispose of garbage at least once a week in the summer—every three or four days is better. Use tight-fitting lids on garbage cans.

The control measures recommended for houseflies are in general effective against blow flies.

Cluster Flies

Cluster flies are slightly larger and slower in flight than houseflies. They can be recognized by the short golden-colored hairs on the sides of the body below where the wings are attached.

The maggots, or immature forms of the cluster fly, live within earthworms. Hence, soils high in organic matter may contribute to the cluster fly problem, by harboring earthworms. Adult flies emerging from the soil are seen on flowers and fruits of plants. In the fall they find their way into houses, apparently seeking shelter. They cluster in large numbers in the attic, basement, between storm sashes and windows, between inside and outside walls, or between screens and windows.

They usually do very little damage but may stain curtain and wallpaper, particularly when flying around windows. These large sluggish flies are often more annoying to householders than the common housefly.

Unfortunately these flies can gain entrance to your home through aluminum siding breathers (3x5 mm.). Before aluminum siding is placed on a home, a thorough check should be made of the sheeting to see that tears and holes

are sealed. Then the siding should be attached carefully and cracks calked before the job is considered complete.

Control:

1. Calk and/or screen all outside openings to attics, walls, and basements. Keeping the insects out of the house is better than controlling them later.
2. For chemical treatment in attics, use deodorized kerosene solutions of insecticides registered for this use. If possible, apply directly on the masses of cluster flies. Spot spray around windows and into crevices and sash cord channels or other places where they can hide.
3. For chemical treatment of outside walls, use an insecticide registered for this purpose, although treatment is ineffective unless you can get the material between the inside and outside walls. Tight construction of outside walls, roof, window casings, foundations and foundation sills to keep them out will be more satisfactory than later attempts at chemical control once they get inside.
4. To control cluster flies in living quarters, use suggestions given for houseflies. Resin strips will kill the flies, but should be restricted to the attic.

Face Fly

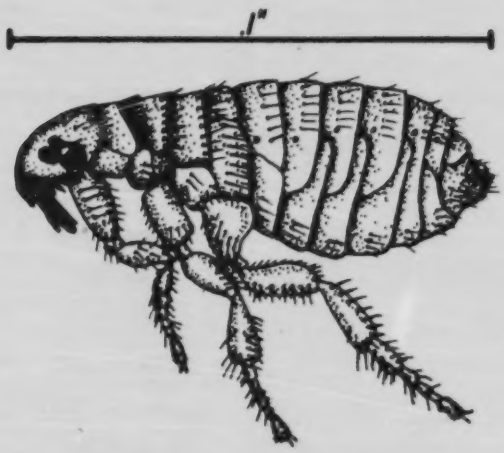
The face fly resembles the housefly very closely but is darker and larger

Females have a grayish-green abdomen and are hard to distinguish from the housefly. (With a magnifying glass one sees that the female housefly has a golden stripe around the eyes while the female face fly has a silver colored one.) Females feed on secretions about the face of livestock, lapping animal secretions from under and around the eyes, from the lips, and in and around the nostrils, hence the name. Larvae feed in fresh cow dung.

Males have a yellow abdomen with a black line down the center, and eyes that almost touch. They feed in summer on nectar and pollen; they are not found on animals.

By seeking shelter in the fall, face flies cause bother in houses much as do cluster flies. For control, follow suggestions for cluster fly (or housefly information where suitable).

FLEAS



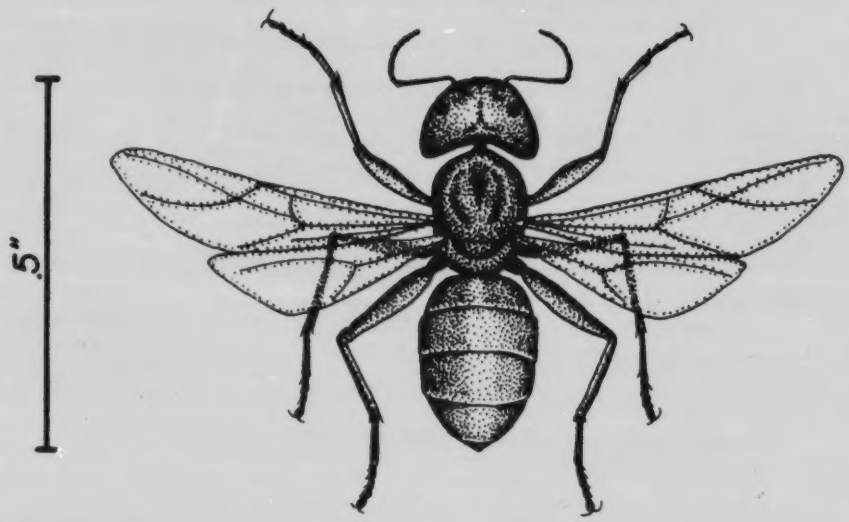
Most flea infestations in Michigan are associated with pet dog or cats but may sometimes originate from rodents or rodent nests located in, or near, human habitations. Fleas lay their eggs among the hairs of their animal host or in the host's sleeping places. The eggs drop or are shaken off and tiny, cylindrical, legless, larvae hatch and feed on various animal and plant substances that have accumulated in floor cracks, under carpets, in nest materials or in other sheltered places—both inside and outside.

When mature, the larvae spin small silken cocoons and develop into the pupal or reating stage, emerging later as adult fleas that feed upon blood. Full development from egg to adult may require several weeks or several months, depending upon the environment.

To be effective, any control effort must be directed against both the adult fleas on the animal and the adult and immature stages located throughout the area frequented by the dog, cat, or rodent host. Frequent, thorough cleaning will help prevent outbreaks of flea infestations in building. This should include vacuuming floors, carpets, rugs and upholstered furniture often, and careful cleaning of cracks and crevices in the floor, around furniture cushions, and sleeping areas used by cats and dogs. Rodent nests in, or near, buildings occupied by humans or pets should be removed and burned. Before removing rodent nests, the nest and surrounding area should be treated thoroughly with insecticide to kill any fleas that may be present.

Effective control of fleas requires treatment of both the premises and infested animals. Flea infestations on pet dogs or cats can be eliminated by applying an insecticide to the animal and normally is accomplished by the owner or a veterinarian. If pets run freely outdoors, treatment must be repeated as often as necessary. Infested sites within the occupied building should also be sprayed or dusted with a suitable insecticide at the time or immediately after the animal is treated. The insecticide should be applied to the floors of infested rooms (including the basement), rugs, mats, sleeping quarters of pets, and their bedding. Yard or outside infestations can be controlled by treatment with a residual spray or dust. Insecticides do not kill flea eggs so the materials selected for control should be chemicals that have a residual activity. If non-residual materials, such as pyrethrum, are used, reapplications will be necessary.

ANTS



Ants are among the most abundant of animals and are found under both arid and humid conditions in the tropical, temperate, and upper temperate regions of the world. They feed upon every food consumed by man and are troublesome household pests. Some ants feed predominately on sweets, whereas others prefer meats and grease. Ants may be rare vectors of the organisms causing enteric diseases from feces or garbage to human food. All ants bite, and some ants sting. Reaction to ant bite or ant sting can be severe in sensitive individuals. Fire ants, which have a highly venomous sting, are a major problem in parts of the southeastern United States. Ants act as scavengers and predators of many harmful insects.

Ants are distinguished from other insects by having the first one or two abdominal segments reduced into a knobbed pedicel or stalk situated between the thorax and the abdomen proper, and by their elbowed antennae. Termites have a broad connection between the thorax and abdomen, and straight beadlike antennae. The forewings of ants are larger than the hind wings and have comparatively few veins, whereas the two pairs of wings of termites are similar in size and appearance and have many veins. Ants have chewing

mouthparts, their heavy mandibles being suitable for biting, piercing, cutting and gnawing. The smallest ant is less than one-sixteenth inch long, and the largest ant attains a length up to one and one-half inches. They are among the most abundant of living creatures infesting the home. Ant colonies may last many years, some of them longer than the three score and ten years allotted to man. The colony is established when the newly mated female discards her wings, digs a nest, and produces eggs for a new brood. After nourishing her young through the larval stage, her labors are over as the larvae pupate and the young workers emerge and take over the work. The worker ants feed the queen, fight off all enemies, construct a maze of tunnels, and care for the young. When the colony has become strong, a special brood of males and females is reared to establish new colonies. These winged adults emerge for their marital flight in vast numbers in order to mate and seek new harborage. Ants have a highly developed social system. In some species each colony is made up of three main castes: the female or queen, the workers, and the males or drones. In other species there is also a soldier caste. An active colony will usually contain eggs, larvae, and pupae (cocoons with pupae are often called "ant eggs"). In this social system the workers perform all tasks including feeding and caring for members of other castes.

In Michigan the following ant species may occasionally be of some medical significance:

Carpenter Ants, "Camponotus spp."

These very large (6 to 10 mm.) ants are black or dark brown. They nest principally in wood which they hollow out into extensive systems of galleries (Fig. 7-28b). They do not eat the wood, but feed on honeydew. They are also predaceous on other insects. They do not sting, but will bite readily. Several species are widely distributed throughout most of the United States. While these ants can damage trees by removing the supporting wood, they enter old scars and do not normally penetrate the bark and healthy cambium. In limited areas, they can cause severe damage to buildings by nesting in supporting structural timbers.

Thief Ant, "Solenopsis molesta"

This yellowish ant is one of the smallest in the United States. It is named the thief ant because it often nests near other ants and raids their galleries for food. Its own galleries are very small, and it cannot be followed by the ants whose nests it raids. It is rarely seen out of doors, as it does not typically forage for food above ground. It is an omnivorous ant, feeding on a wide variety of available plant and animal materials. It is predaceous on insects and other small animals. The thief ant can sting, but rarely does so. The secreal subspecies and varieties are generally distributed throughout the United States. This ant readily invades buildings, and is one of the most important household ants. Because of its size, it can nest in very small cracks. In buildings it will forage widely for sweet, starch, and protein foods, but prefers greasy materials.

Pharaoh Ant, "Monomorium pharaonis"

This small ant (1.5 to 2 mm.) varies in color from yellow to red. It can be distinguished from the thief ant because it has three segments in the antennal club whereas the thief ant has only two. It will nest almost anywhere —in cracks and crevices, under stones and boards, and around foundations. It feeds on sweets, greases and proteins, and is predaceous on many insects. It is widely distributed throughout the United States. It is an important and persistent pest in buildings where it will forage for food and for moisture. This ant cannot sting but will bite readily. This ant may be a serious pest in hospitals where it sometimes invades nurseries, feeds on wounds, and gets under casts.

Control

1. Some ant control techniques can be used in buildings. Others are suitable for use only outdoors. The control of some ants requires techniques developed for the particular species rather than normally used for other ants. Inside buildings,sanitation carried out by building occupants is an important aspect of ant control. Crumbs,

grease, food scraps, and foods in open or semiopen containers are readily found by foraging workers, and can attract large numbers of ants. Heavy infestations in buildings are rarely found where good sanitation is practiced.

2. Dusts are tracked into the nest by the workers. They are usually more effective than sprays. Dusts are blown directly into the nests, or are applied in all cracks and crevices several feet each side of points of entry.

3. Sprays can reduce ant populations indoors, even if ants enter buildings from outdoor nests; but they are not effective in eliminating the colonies. All points of entry should be treated, as should the areas several feet on each side. Foraging areas, other than food preparation surfaces, should also be treated.

4. Poisoned baits can be used effectively if they are more attractive to the species present than other available foods. Baits are taken into the nests, and are fed to the larvae, the reproductives and the soldiers. However, the poisons must be slow acting to provide control, as fast-acting poisons kill the workers before the bait is distributed. Ant baits are not available as standard stock items. If open purchase items are used, the manufacturers recommendations for use should be followed, and care should be taken to avoid possible food contamination and contact by children and pets.

5. On the outside, dusts may be blown directly into nests, followed by clean air to distribute the dust within the galleries. Dusts are also used for barrier treatments in which bands 4 to 6 inches wide are used to ring the nests. A clean area several inches wide should be left between the ring and the nest entrance. Several applications may be required in wet or windy weather. Mound-building ants often enter and leave nests through tunnels at a distance from the

mound and control may require treatment of areas 10 feet or more in radius.

6. Sprays are used to saturate nests after the mounds are opened with a hoe. Oil-base solutions should not be used in vegetated areas. Emulsions must be used with care, as they can burn some foliage. Suspensions are the safest sprays to use outdoors. They are effective for area control where there are many small nests or where nests are hidden but the foraging areas are known. The area should be wet down thoroughly. After the water has dried, the residual dust is tracked into the nests by the worker ants. Poisoned baits can be used for the control of some ants.

7. Carpenter ants are best controlled by treatment of the nest. Only dusts should be used. Oil solutions can soak through wood to stain walls; and the water in emulsions and suspensions can cause swelling and warping of wood and can lead to decay. Dust should be introduced into the top of the nest if it can be found by tapping and drilling. Where the nests cannot be located, area control is required. Emulsions or suspensions are effective for use around foundations, in attic spaces, and in other areas where ants are seen.

STINGING INSECTS

Ants, bees and wasps are all members of the order Hymenoptera. These are membrane-winged insects, though not all members of this order have wings. Ants have wings only in the reproductive forms. In the mutilid wasps or velvet ants, all females are wingless, though most males have wings. Many of the hymenoptera live solitary lives; yet this order contains most of the "social insects" which have caste systems with workers and soldiers in addition to reproductive forms all living in single nests or hives. This system is best developed in ants, some of which have several types of

workers and soldiers. Bumble bees, honeybees, and wasps have workers in addition to reproductives. Mud-daubers have no worker caste. A great many hymenopterous insects are beneficial to man in that they parasitize or prey upon insects which are destructive of useful plants. The various sting mechanisms in these parasites and predators are modified ovipositors. The venom produces lethal or narcotic effects in the arthropods intended as food for adults or larvae. The stings of many of the hymenoptera are also very well suited for defensive use. While truly "unprovoked" stinging of large animals is considered quite rare, very little provocation is needed to incite some wasps and ants to attack intruders in the areas of their nests. Whatever their reasons for stinging, the hymenoptera kill more people in the United States each year than do snakes and spiders combined.

Wasps

More than 2,500 species of wasps occur in North America. About 50 of these are troublesome to man. They are divided into hornets and yellow jackets (*Vespa and Vespula) Polistes* and mud daubers (*Sceliphron, Chalybion, and Tryposylon).* Wasps can be identified by their structure and by the nests they build. Hornets and yellow jackets are built more stockily than potter wasps and mud daubers. They are black, and have yellow or white markings. The queens are about three-fourths inch long and the males and workers are about one-half inch long. They are black, brown, or red, and have a few yellow markings. Mud daubers are also slender and three-fourths inch long. They are black and yellow (*Sceliphrone)*, metallic blue (*Chalybion)*, or shiny black (*Trypoxylon)*.

YELLOW JACKETS

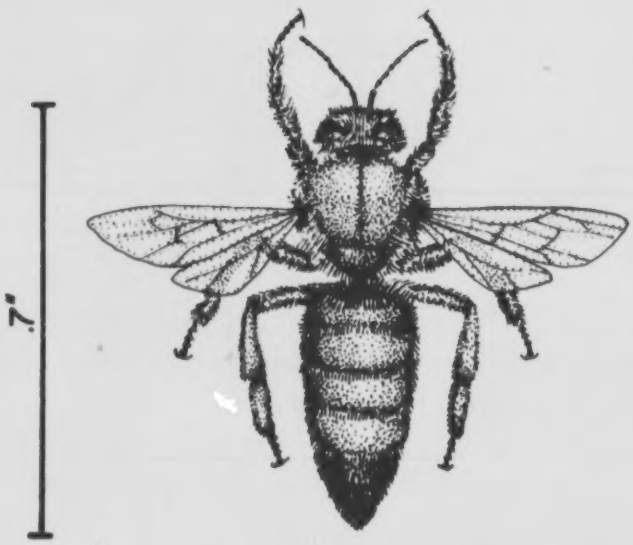
Nests of hornets and yellow jackets are globular, papier-mache structures concealing multicombed structures. The nests are usually above ground, but some species nest underground. Polistes nests are singled-layered, open faced, and umbrella shaped, the size of the wasps' nests depends upon the number of wasps living in them; and they are enlarged to accommodate the growing population. A single hornet or yellow jacket nest may have up to 15,000 workers and several hundred queens and males. A mud-dauber nest consists of several clay cells. After placing one egg and several paralyzed small spiders in each cell, the female caps the cell,and abandons the nest. Upon emerging, the new mud-daubers leave the nest, and carry on their activities independently.

Wasps, hornets, and yellow jackets develop in the same way. The three adult forms are fertile females (queens), which lay the eggs; fertile males, which mate with the queens; and workers, which are females and usually sterile. Generally, in the fall, queens and males leave the nest and mate. The males die shortly thereafter, but the queens hibernate in the cracks in rocks, under loosened bark of trees, in buildings, or in holes in the ground. Polistes queens also hibernate in attics and basements. The following spring the queen comes out of hibernation and begins flying about until she comes upon a suitable nesting site. She then collects wood or other vegetable fiber from nearby plants, chews it into a paperlike substance, constructs a comb of a few shallow cells (later enlarged into a nest), and lays an egg in each cell. She does not lay any more eggs until her first brood develops. After the eggs hatch in 2 to 3 days, the larvae hang head-down in their cells. The queen protects the larvae of the first brood, feeding them daily with freshly killed insects. After 12 to 18 days, the full grown larvae spring cocoon caps over their cells and transform into pupae which remain motionless within their cocoons. After about 12 days, the pupa stage is completed and the adults emerge. Upon emergence of the first brood of workers, the queen resumes egg laying. The larvae of the first brood develop into workers which care for the larvae of subsequent broods. Mud-daubers have no workers. The female builds a nest of several clay cells. She puts several small paralyzed spiders and one egg in each cell which she then caps with clath. After hatching, the larvae feed on the spiders for several days; then they pupate. In about 2 weeks the adults emerge to start new nests.

Control efforts are directed toward treatment of nests and surrounding areas. Insecticides may be used as dusts, wettable powders, solutions, or emulsions. If oil-based solutions are selected, they should be used with care around vegetation to avoid damage. Most wasps will be at their nests at night, and they will be least active then. Dusts are easy to apply to some hornets' and yellow jackets' nests whether above or below the ground. The extension tube on a hand duster can be inserted into the nest opening. Two or three strong puffs of dust will filter through the nest, and will usually kill the colony within 24 hours. Solutions and emulsions should be sprayed into and onto the nests. The more nearly saturated the nest, the quicker the kill. Rapid

garbage disposal will reduce the numbers of some species that congregate around garbage. The spraying of garbage containers once a week, particularly around the tops will help control wasps attracted to garbage. Residual sprays are effective for control of wasps in buildings. Screens, window frames, doorframes, and other places where wasps generally crawl should be treated.

Bees



Like the wasps, bumble bees overwinter only as fertilized queens. In the spring, a new queen finds a nesting site, partially fills it with a mass of dry grass or moss, adds a ball of "bee bread" (a mixture of pollen and nectar), then adds eggs. She stays to care for this first brood until the new workers take over all of her duties other than egg laying.

The life cycle of the honey bee is different. After the mating flight of new queens, the old queen will leave with a number of workers (a swarm) to start a new hive. Only one of the fertile new queens is able to return to the old hive where she begins laying eggs. A single queen may lay 1,500,000 eggs in her 3 to 5 year life, and may have as many as 100,000 offspring living at one time.

Of the many types of bees, those most commonly responsible for stinging man are the bumble bees and honey bees. Bumble bees are large, furry, black and yellow or black and reddish, haired bees. In flight they make a loud buzzing noise. Their nests are located in cavities in the soil, often in abandoned nests of field mice. A single nest in late summer will have the original queen, workers representing several broods, and a number of functional males and females. Honey bees are typified by their moderate size, hairy eyes, the ability of the workers to sting only once, by pollen baskets on hind legs of workers, and by the strict caste system in which the queen performs no duties other than egg laying. She is without the pollen basket on the hind legs. The honey bees are not native to North America, but were introduced by early colonists. The nest is the manmade hive except for those bees that have "escaped" domestication and have established hives in hollow trees and in attics and wall spaces of buildings.

Many beekeepers will remove a colony without any charge. This is an effective and satisfactory method when it can be used. Insecticides may be used to spray the hive when it is accessible. When the hive cannot easily be reached, residuals may be applied to small holes through which the bees will pass.

HONEY BEES

SELF HELP QUESTIONS ON INSECTS

Now that you have studied the section, answer these questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if you are correct by checking them in the text. Erase your answer and write in the correct answer if your first answer is wrong.

1. How do insects affect man?

2. What disease is transmitted by the housefly?

3. What is meant by the term "myiasis"?

4. What are the three common species of cockroaches in Michigan?

5. What conditions favor an increase in human lice?

6. What is recommended for control of bedbugs?

7. Will larval or adult control of mosquitoes give the more long-lasting results?

8. Where do blackfly larvae develop?

9. Where do stable flies lay their eggs?

10. Why is sanitation so important to effective control of the housefly?

11. What are three common species of ants that are pests in Michigan?

12. Where should insecticides be applied to control wasps?

OTHER ARTHROPODS THAT AFFECT MAN

MITES

Listed below are the mites that are known to attack or annoy humans with some frequency in the United States.

Mites That Attack Man

From birds:

Chicken mite
Northern fowl mite
Tropical fowl mite

From other vegetable matter:

Straw itch mite
Furniture mite

From Rodents:

Tropical rat mite
Mouse mite

From vegetation:

Chiggers

Living on man:

Itch mite
Follicle mite

From food materials:

Grain mite
Mushroom mite

Mites That Migrate From Birds

Chicken mite: This mite is the best known of the mites infesting poultry. It is found on the birds only when it is feeding, which is normally at night. In the daytime it hides in cracks and crevices in the vicinity of the roost. The chicken mite will feed freely on many birds other than chickens, including pigeons, canaries, sparrows, swallows, doves and wrens. When the mite attacks man it causes a mild dermatitis and itching. Cases of dermatitis caused by this mite undoubtedly are common in rural areas but several cases are on record from cities. They include instances where the infestations were traced to pet canaries, pigeons and nests of other wild birds. There are some cases on record of the death of the bird host or its departure from the nest bringing on the attack on man. It is believed that this species can live for several months without food, so positive methods of eradication are required where they are a problem.

Northern fowl mite: This mite is very similar to the chicken mite in appearance but is very different in its habits in that it breeds among the feathers of the host bird and the mites may complete their development without leaving the host. It is not necessary for this mite to stay on the host, however, and they may be found in nests, or roost areas, and in surrounding cracks and crevices. They can survive for two or three weeks away from the host.

This mite may bite man, causing some annoyance. There are reports of it causing a dermatitis but they do not appear to be as frequent as reports of dermatitis from the chicken mite. The most frquently reported trouble is irritation from the occasional bite inflicted by wandering mites. The source of the infestation may be quite varied, for this mite is a general parasite of birds, found on domestic fowl, sparrows, swallows and many other species. It is found throughout the temperate region. Annoyance of man is frequently associated with the death or departure of the normal host bird leaving an infestation of

mites behind in the nest area without a convenient source of food.

Tropical fowl mite: This mite is very similar to the northern fowl mite but is found more frequently in tropical regions. It has not been reported often or from a wide area.

Mites That Migrate From Rodents

Tropical rate mite: This mite is associated with rats throughout the United States. It will feed on man and many other warm-blooded animals. The bite on man is painful, causing intense itching and a skin irritation known as "rat-mite dermatitis." The mite has not been proved to be a transmitter of typhus or other diseases, although its habits appear to suit it well for such a role. The attack on man is almost always associated with rats in buildings, and complaints are common from areas which may be infested with rats, such as warehouses, stores, theaters, and apartments. Killing of rats may intensify the attack on man, but this mite will bite man even where there is an abundance of rat hosts on which they can feed. The mites drop from their host after each feeding and may be found on a variety of surfaces near rat-infested areas. They can survive for several days without a blood meal.

Mouse mite: This mite in the United States is primarily a parasite of mice. It tends to leave its rodent host to wander throughout buildings and bite man. Its major importance is that it has been identified as the vector of rickettsial pox, a mild and nonfatal disease of man.

Mites That Migrate From Food Materials

Grain mite: The grain mite is commonly found infesting all types of grain flour. It also may be found on other stored foods, being one of the mites reported from cheese. It prefers a moist location and under favorable conditions develops rapidly and in great numbers, completing its cycle in as little as 17 days. Under adverse conditions it may lengthen this period a great deal. The second nymphal form may be replaced by a special stage known as the "hypopus." This stage is highly resistant to unfavorable conditions, insecticides and fumigation, and it may exist for several months without feeding. The hypopus does not move much under its own power, but it is transported from place to place by clinging to small animal forms such as insects or mice. When it

encounters favorable conditions it sheds its skin and resumes normal growth and development. The peculiar adaptation through the hypopus stage makes it very difficult to eradicate this mite.

The grain mite and related mites are reported to have been the cause of mild dermatitis in man, known under various names as "grocers' itch," "vanillism" (from infestations on vanilla beans), and "copra itch." These cases are reported where products infested with the mites are handled by man. These mites are not blood-sucking forms and thus are the cause of only mild irritations, very easily remedied once the source of exposure to them in large number is eliminated.

Mushroom mites: This mite is a common pest of mushroom beds, but it also may be found in huge numbers on such materials as cheese, dried meats, cereals, and many other materials found commonly in homes or food storage. As with the grain mite, it is not a blood-sucking form, and any dermatitis from it would be a somewhat superficial irritation easily eliminated by the destruction of the source of the infestation. This mite is capable of reproducing in enormous numbers and may quickly overrun an entire area surrounding its source of food.

Mites That Migrate From Other Vegetable Materials

Straw itch mite: The straw itch mite normally lives on other insects. Common hosts are the larvae of several insects such as the wheat jointworm; the wheat straw-worm; the Angoumois grain moth; the rice, granary, bean and pea weevils; and the pink boll worm. It reproduces rapidly and in enormous numbers. This mite has an unusual development. The eggs hatch within the body of the female and the young are matured within the body of the mother. They are born as sexually mature adults. It is reported that a single female may give birth to over 200 adult mites and that in one week the females of this brood will have produced another brood in the same manner.

Men who are engaged in threshing straw or handling grains or other material infested with the insect hosts often are overrun by these mites. Their bites produce a rashlike dermatitis which may cover large areas of the body. The rash appears in about 12 hours after the attack and is accompanied by a severe itching. The attack is often of such intensity as to induce vomiting, headache, sweating and fever.

The attack of man by this mite was a common observation in times when it was the custom to sleep on straw mattresses, but in recent years reports have been relatively infrequent. An interesting report was given this year of the recurrence of this mite as a pest of man in Ohio and of the association of this problem with the appearance of a heavy infestation of wheat jointworm in Ohio wheat for the first time in 30 years. The most striking case was that of 4-H club boys showing their animals at country fairs when they became infested from the straw which they were using to bed their animals and on which they themselves were sleeping.

Furniture mite: This mite is a common pest of furniture in Europe and has frequently been intercepted on shipments from there. It is common in this country, but we have no record of it as a household pest. It feeds on vegetable matter, apparently having a particular liking for certain materials used to stuff furniture. It is very similar in habits to the grain mite. It does not feed on blood but has been reported to be the cause of "grocers' itch" in the same way as the grain mite.

Mites That Migrate From Outdoor Vegetation

Chiggers: Chiggers which attack man are the larval stage of a mite. The species commonly encountered in the United States is *Eutrombicula alfreddugesi*. Other species may be found less frequently.

These mites are distributed over approximately the eastern half of the country. They are most common in the southern states, but frequently are abundant during the summer in the more northern states. They infest a variety of areas ranging from those overgrown with brush to well-kept lawns.

Adults of the mite overwinter in earthern cells in the soil. This stage does not attack man, but is a scavenger living on decaying matter. In the spring these adults emerge from the soil and lay their eggs. These hatch into tiny oval orange-colored larvae. It is this form which attacks man. Normally these larvae live on snakes, turtles, rabbits, birds and other wildlife. They also feed on man and domestic animals. These larvae can barely be seen with the naked eye. They are very active and crawl about rapidly in search of a place to feed. When man comes in contact with vegetation infested with these larvae they may swarm over his body. It may be several hours before they settle down to feed. Their attack seems to be concentrated at points where the clothing is pressed against the skin, as under belts or garters. They attach themselves, frequently near a hair follicle, by their mouthparts and first pair of appendages. In feeding, the mite injects into the host a fluid which liquifies the immediately adjacent tissues. The liquified tissues are ingested by the mite. The surrounding tissues become hardened, and, as feeding progresses, form a tiny tube through which further liquified tissue may be withdrawn. The larva becomes fully fed in four to six days when it drops off the host, leaving behind the tube which has developed from its feeding activity. The digestive fluid of the mite causes a severe itching and a definite dermatitis. Scratching of these areas may lead to secondary infection. The itching may last for a week or more. This mite is not associated with disease transmission in the United States.

After leaving the host the larva transforms to a nymph and later to the adult. Neither of these forms attack man or animals, but feed on vegetable matter.

Mites That Live On Man

These mites are the true parasites of man. They are not a problem for the non-medical personnel. They are strictly problems for the medical doctor.

Itch mite: This mite causes scabies or itch in man. There are several closely related forms on animals which may sometimes transfer to man, but usually close contact is required and the problem is not one where the pest control industry is usually consulted or can offer any assistance of value.

Clover Mite

General remarks: Clover mites were first noted as a serious problem in structures in the eastern United States about 1950, and since then have become a problem throughout much of the country. They are usually associated with new lawns and, therefore, are a problem mostly in new suburban areas.

Clover mites are not insects, but are related to chiggers and other mites. Clover mites often invade homes during the fall, winter or spring where they are a nuisance and may cause stains when crushed. Unlike the other mites PCO's are likely to encounter in structures, clover mites do not attack man. They do suck the juices of grasses, clover, and a variety of other plants outdoors.

Description: The mature clover mite is a reddish-brown, eight-legged creature, slightly smaller than the head of a pin. The young are smaller and redder. The front pair of legs is much longer than the other legs and characteristically extend forward from the body. The long pair of legs can be seen with a hand lens and serve as a good way of distinguishing the clover mite from other mites of a similar size and color.

Life cycle: The bright red eggs of the clover mite are laid singly or in masses in cracks and crevices in building walls and beneath bark on trees. Favorite spots are the minute depressions on masonry surfaces and on rocks and wood debris on the ground. The summer is usually spent in the egg stage, but active stages may be present during the summer in cool spots in the north.

Hatching occurs between 40° and 85°F.; therefore, most hatching and mite activity occurs during the fall and spring. Above 86°F., the eggs remain dormant and do not hatch.

The newly hatched mites migrate to grasses, clovers, and other plants to feed. After feeding, the young mites return to their hiding places on the trees or swellings to molt. The clover mite goes through three such molts before becoming an adult, and migrates to a food source between each molt. Each developmental stage lasts two to six days under ideal conditions. The adults migrate between the dwelling and the food source several times during their life span. Male clover mites are very rare in this country, but mating is not necessary for young to be produced. Females produce about 70 eggs each.

Commonly there are three to five generations produced each year. All stages may be present during the winter. The mites hibernate in the same types of places that are used for egg deposition.

Habits: Clover mites use concealed spots in which to lay their eggs, hibernate, and hide during molting periods. Typical places of concealment are cracks and faults in concrete foundations, mortar crevices, under shingles and siding, on building paper between the walls of buildings, under window sills, around sub area vent frames on the "in" side, and on the underside of the lower bark on trees. Eggs are also laid on accumulations of small stones, bits of wood, etc.

Most clover mites tend to move less than two feet from their hiding places to feed when food is close at hand. Therefore, feeding usually takes place close to foundations or tree trunks.

Foraging occurs when temperatures are between 50° and 70°F. Remember, however, that the temperature in a microhabitat may be higher than the surrounding air temperature. On a cold winter day, the south side of the house close to the foundation may be warmed enough by the sun to stimulate clover mites to seek food.

When the hiding places of the mites become warm enough to stimulate activity, the mites begin to move, perhaps in search of food. Such movements of mites hiding within the walls of buildings may bring the mites in contact with the warmer air of the interior of the house. The mites apparently move towards this warm air and enter the interior of the house through cracks along baseboards, doors, or windows.

This may occur periodically throughout the winter, (especially on the south side of buildings) whenever temperatures in the hibernating places become high enough to stimulate activity. Activity is greater in the spring and fall, but as outdoor air temperatures become more favorable, there is less tendency for the mites to migrate to the interior of the building.

Feeding: Clover mites feed on grasses, clovers, and some other plants (both desirable and weed species) around buildings and on lawns. Although white clover is a highly preferred food in some places, Kentucky bluegrass, bentgrass, red fescue, red top and chickweed seem to be preferred in most situations.

Lush lawns which are well fertilized, especially with organic fertilizers, tend to have larger populations. As lawns become older, clover mites are less of a problem. It is not known if this is due to a poorer lawn care program, different nutrient levels in the food plants, a buildup of natural predators, or a combination of these and other factors.

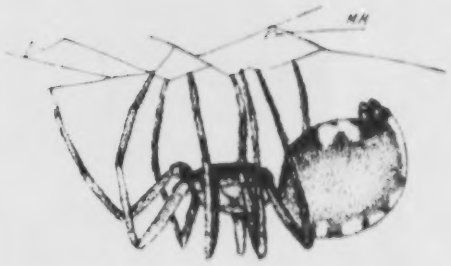
Clover mites feed by puncturing the plant tissue and sucking out the juices. Feeding usually occurs when the temperature is between 50° and 70°F. The time of day feeding occurs varies with the season and temperature. Late fall and early spring feeding occurs on grass, etc., growing in sheltered spots near foundations or other protected spots warmed by the sun. Public health workers should observe tufts of plants in such sheltered spots for indications of clover mite problems.

Economic importance: Clover mites are, for the most part, nuisance pests. Their mouthparts cannot pierce human skin and they do not feed on clothing, draperies, curtains, rugs, parts of a structure, or foodstuffs. If crushed, they leave stains on walls, curtains and other materials.

They do not ordinarily attack plants within a dwelling and they usually do not do enough damage to lawns to warrant control for this alone.

They are transported in a variety of ways such as by wind, in new sod, and on new plants. They may migrate from a neighbor's lawn.

SPIDERS



Many people fear spiders because of myths that surround them, or the publicity that has been given to the very rare fatal poisonings by a few species. Others object to these creatures because of their annoying habit of building webs in corners, on furniture, or across doorways and in other places. Under some conditions spiders are considered beneficial because they feed on insects to which they are distantly related.

Description

Spiders have a characteristic appearance recognized by most people. Their eight legs immediately separate them from insects which have only six. Spiders lack wings and antennae. Their bodies have but two regions—a cephalothorax (fused head and thorax) and an abdomen. Young spiders, or spiderlings, resemble the adults except for size and sometimes coloration. Males are usually smaller than females of the same species.

The eight legs of a spider are attached to the cephalothorax which also bears the eyes and mouth parts. Most spiders have eight eyes, but some species have only six, and a few have less or none. All spiders have a pair of jawlike structures *chelicerae* at the end of which is a hollow, clawlike fang. Each fang has a small opening in the end through which venom can be ejected.

The abdomen of spiders contains their reproduction system, and largest part of their respiratory system and the spinnerets. The latter are the silk spinning glands and are located at the tip of the abdomen.

Spider Bite

Spiders are seldom aggressive towards humans and usually bite only when injured or trapped. Only the large spiders are capable of breaking the tough skin of a human being; the smaller ones can inflict only superficial scratches.

Nearly all spiders have venom glands, but almost all of the United States species have a venom so feeble that its brief effects are insignificant.

The severity of a person's reaction to the bite of a spider is influenced

by a number of factors. The species of spider and the area of the body where the bite occurs are of great importance, but the amount of venom injected, depth of bite, seasonal changes and temperature, also play a role. The signs and symptoms are caused by the mechanical action of the bite, and/or by the venom. In some case there is no reaction at all.

Injury caused by a bite is partly mechanical and partly due to the injection of venom which is irritating, but in most cases is not toxic. Symptoms are slight soreness and itching similar to a mosquito bite or burning, throbbing, numbness, stiffness, and sometimes a very slight swelling.

Life History

After being impregnated by the male, the female spider begins to lay eggs. The eggs are laid in dark retreats or in silk cocoons called egg sacs. The females of some species guard the eggs, other species carry the egg sac with them. Depending upon the species, a female may produce as few as two, or as many as 3,000 eggs. They are usually laid over a period of time in a series of several sacs.

In warm weather, the young may hatch within three weeks. They tend to remain together for several days before scattering. Cannibalism often occurs during this period. Most of our common species mature within one year, going through a series of molts as do insects. Some species require up to twenty years to reach maturity.

Mating and egg-laying occur anytime of year, depending upon the species. Some species, after overwintering as half-grown individuals, mature and lay eggs in the summer. Other overwinter as eggs, hatch in the spring and mature and lay eggs in the fall

Habits

Spiders cannot fly and, therefore, use other means of dispersing in addition to walking. Some, such as the brown recluse, find many objects transported by man suitable retreats, and can be moved great distances in this manner. The most interesting method of travel is "ballooning," which is practiced

primarily by the young of some species. To accomplish ballooning, the spider climbs to the top of an object such as a plant or fence post and releases a strand of silk. If a wind is blowing, the spider sends out silk until there is enough of it windborne to lift the spider from its perch. Spiders reach great height by this method and are known to have been carried for distances as great as 60 miles.

Some spiders build simple webs and others build very complex webs. Webs usually consist of strong, nonsticky strands of silk which form the framework of the web. These strands are united with a series of silk strands having sticky globules on them. The spiders are just as susceptible as insects to being stuck in the sticky globules, but the spiders are adept at avoiding them. Some types of spiders do not spin webs, but use their silk only for building egg sacs or retreats.

Feeding and Moisture Requirements

Spiders can be separated into two groups based on the way they capture prey:

1. the cobweb spiders, which make webs to catch insects and live all the time in the web or in a nest near it;
2. the hunting spiders, which run on the ground or on plants, catching insects wherever they find them, or waiting among leaves and flowers until insects come within their reach. The species that commonly live indoors are cobweb spiders.

Spiders eat live prey which almost always consists of insects and their small relatives. Victims are killed by the venom which the spider injects through its fangs. Spiders have food preferences, but a hungry spider will tackle most anything that is not too large. Some, if not all species, can go for long periods without food. The brown recluse, for example, has survived for six months without food or water.

Although all spiders require water for survival, some species require very little and can live in dry environments. Many species, however, can live only in humid places and need a regular source of drinking water. Most species are attracted to water sources if such are available. For this reason, you should

first look in areas around water pipes, floor drains, and air-conditioners when trying to determine the source of an infestation indoors.

Habitats

As indicated above, many spiders are associated with moisture, and therefore, are found in basements, crawl spaces, and other damp parts of buildings. Others live in warm dry places and can be found in subfloor air vents, in upper corners of rooms, and in attics. Most species found indoors hide either in cracks, in darkened areas, or in retreats

Outdoors, spiders live in a variety of places depending upon the species. Some hide in flowers waiting for prey. Others live on tree trunks, under stones or leaves, or in or under the eaves. Most of the outdoor living species are not able to adapt to indoor conditions, although some of them can live in attics.

Dangerous Spiders and Their Occurrence in the United States

Few dangerous species of spiders occur in the United States. You need to be especially aware of the widow spiders of the genus *Latrodectus*, and the brown recluse spider and its relatives of the genus *Loxosceles*. Deaths of humans have been recorded from bites of spiders of both groups. Other species of spiders may bite humans and cause irritation. These bites rarely cause serious reactions, but they can become infected.

Brown recluse spider: The brown spider is a soft-bodied, secretive species often found in homes and capable of inflicting venemous bites. Adults vary from three-tenths to one-half inch in length; the average is about four-tenths inch. Males are usually slightly smaller than females. Their color varies from yellow to dark brown, with the cephalothorax (that portion of the body bearing the legs and eyes—a combined head and thorax) usually being lighter than the abdomen. Legs are long and well covered with short dark hairs.

Distinguishing characteristics are the presence of three pairs of eyes arranged in a semicircle on the forepart of the head, a violin shaped dark marking immediately behind the semicircle of eyes; and a somewhat flattened carapace

(hard shell covering cephalothorax) with a distinct short medium groove. The immature stages closely resemble the adults except for size and often a slightly lighter color.

Life cycle and habits. The eggs are deposited in off-white round silken cases, approximately one-third inch in diameter. These cases are found in sheltered dark areas in the spider's habitat. In the summer, young spiderlings emerge from the egg in 24 to 36 days. However, they have hatched from the egg sometime earlier and molted once before leaving the egg case. The abandoned egg case contains the cast skins of the first instar spiderlings. Fifty or more spiders usually emerge from the egg cases in our state. Development is relatively slow and is greatly influenced by weather conditions and the availability of food. With adequate food and mild temperatures, this species can reach maturity in seven to eight months. The spiders are capable of surviving for long periods of time without food or water, up to nearly six months in some tests conducted by the Entomology Department, Oklahoma State University.

The brown recluse spider has been reported from most parts of Oklahoma and many of the surrounding states including Kansas, Missouri, Arkansas, Texas, Louisiana, Mississippi, Alabama, and Tennessee. It is usually found indoors in all types of buildings; and when in homes, particularly in bathrooms, bedrooms, closets, garages, basements, cellars, etc. It can be found hiding in old clothes, on the underside of tables and chairs, behind baseboards and door facings or in corners and crevices. The web is not elaborate and is best described as an off-white to grayish nondescript "cobweb" type of webbing. The web is not used particularly for catching food, since this spider is a hunter rather than trapper, but for more of a place to "hang its hat." The spider is not aggressive and usually runs for cover when disturbed. Most bites occur when a person crushes the spider when putting on old clothes that have been hanging in a garage or by rolling on the spider in bed while asleep.

Brown recluse spiders live both outdoors and indoors. In Oklahoma they find shelter under stones, boards and other objects. You may also find them against foundations and in crawl spaces. Individual spiders are outside even in the winter.

Brown recluse spiders show a preference for concrete-block buildings, although you may find them in all types of buildings. They hide in cracks, crevices and other dark recesses. They favor storage areas such as closets and attics. Unoccupied houses vacant for short periods are notably lacking in brown recluse spiders. However, lofts of resort cabins vacant for four or five months at a stretch commonly have infestations. Grain bins commonly have these spiders.

Infestations have become a problem for utility companies, whose transformer boxes and electrical switch gear often shelter the spiders. Station and line maintenance personnel should become aware of the spiders and the dangers associated with them. In areas known for spider populations you should contact utility companies to offer your services.

Effects of the bite. The victim may not be aware of being bitten for two or three hours, or a painful reaction may occur immediately A stinging sensation is usually followed by intense pain. A small blister usually rises and a large area around the bite becomes congested and swollen. The victim may become restless and feverish and have difficulty in sleeping. The local pain is frequently quite intense, and the area surrounding the bite remains congested and hard to the touch for some time. The tissue affected locally by the venom is killed and gradually sloughs away, exposing the underlying muscles. The edges of the wound thicken and are raised while the central area is filled by dense scar tissue. Healing takes place quite slowly and may take six to eight weeks. The end result is a sunken scar which has been described as resembling a hole punched or scooped from the body. Scars ranging from the size of a penny to half-dollar have been reported.

In the case of a bite, the victim should immediately consult a physician, and, if possible, bring along the spider which caused the bite for positive identification.

The widow spiders: The most common and most dangerous of all the widows is the black widow, *Latrodectus mactans*. The black widow is decreasing in importance as a dangerous spider because fewer outdoor toilets are in use today and this is where many of the bites occurred.

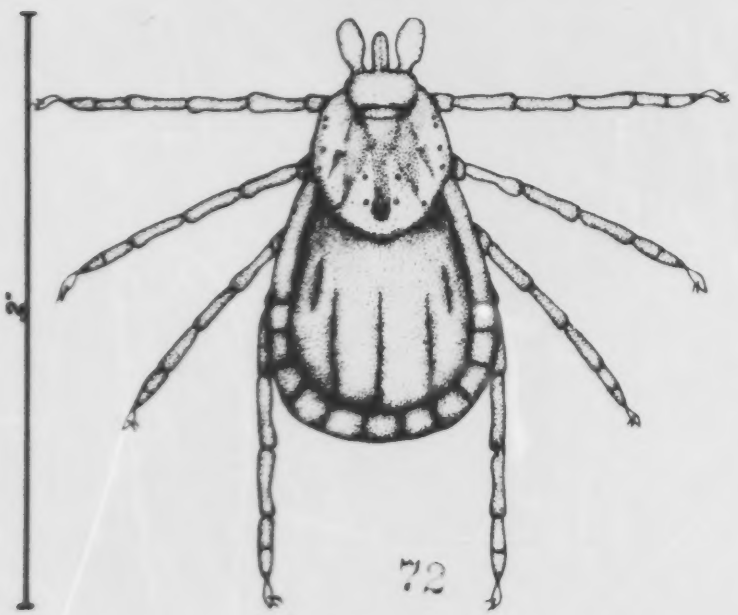
There are several subspecies of this spider and some authorities recognize *L. variolus*, the "northern" widow, as a separate species. All of these widows are potentially dangerous and for practical purposes, you do not need to be able to distinguish among them. Death results in about 5 percent of the untreated cases of black widow spider bite.

Description. The female black widow is shiny jet black on the upper surface of the body. On the underside of most specimens is the characteristic red mark shaped like an hour glass. Some specimens have this mark divided into two spots. There may also be one or more red spots above the spinnerets near the tip of the abdomen. The body of a full grown female is about half an inch in length, but the body of the male is only one-seventh or one-sixth of an inch long. Only the female widow is usually considered to be dangerous, but the bite of a male may be hazardous to a small child or a very sick person.

Habitat. The black widow may enter residences, but is usually found in garages, sheds, outdoor toilets, culverts, and similar places. Its web is loosely woven and irregular, and at or near ground level. Some of the subspecies tend to live away from man and build webs several feet from the ground.

There are two other species of widows which are less dangerous and found only in Florida. They have similar habits except they tend to live off the ground in trees or shrubs.

TICKS

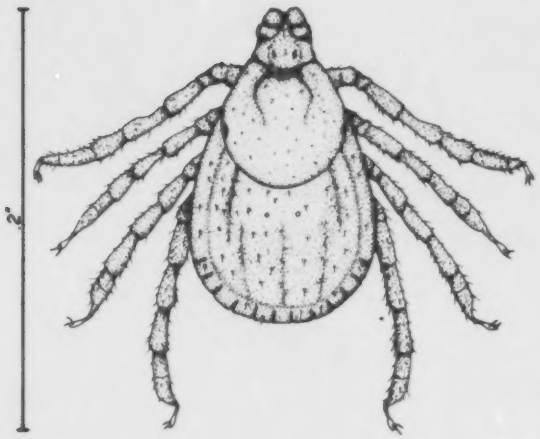


While ticks common to Michigan do not normally present problems, large numbers of American dog ticks, *Dermacentor variabilis*, have occurred recently in certain areas. They usually can be successfully managed without extensive use of insecticides if the habits of the tick are understood and control measures designed accordingly. Problems with this tick in Michigan have invariably been associated with the presence of small rodents—field or meadow mice, rabbits and similar animals. Humans or dogs usually encounter ticks by passing through an area frequented by these small rodents. Female American dog ticks lay their eggs in protected areas of the soil and may deposit several thousand in just a few days. Immature ticks (the larvae) hatch from the eggs and climb up on low vegetation along the pathways followed by small animals. They drop onto these small animals, or grasp their hair as they pass by. Attaching itself to the animal, the tick engourges with blood, and drops to the ground after feeding is completed. There it develops into the next stage, the nymph. Nymphs repeat the feeding process of locating a suitable host and taking a blood meal.

Adult American dog ticks usually attach to humans and larger wild and domestic animals, including dogs, but immature stages rarely do so. Tick larvae, nymphs and adults usually require several days of attachment to become fully engorged and complete their blood meal. The normal life cycle of this tick species is two years, but may be as long as four. These ticks are most apparent in Michigan from late spring (when the adults emerge from their winter seclusion) through early summer, but are rarely encountered later in the year. Ticks of this species can transmit Rocky Mountain spotted fever, known to have occurred in Michigan, but never a significant health problem here.

Major American dog tick infestations in Michigan have usually developed in the vegetation along paths or trails used by humans, and in or adjacent to dog exercise areas in yards, roadside parks or similar localities. Effective tick control can be obtained in these areas by mowing or removing the vegetation for several feet along each side of the path or trail. This removes the cover used by the small animals and ticks. Insecticide applications may be needed if the infestation is particularly heavy.

Another tick, the brown dog tick *Rhipicephalis sanguinius*, has created a severe annoyance in some localities where it has infested domestic pets and become established inside buildings. Normally a parasite of dogs, this tick is brought into the building on the infested dog during the summer. Inside, infestations are usually noted until winter or early spring. Eggs laid indoors by these ticks in the summer hatch and produce the large number of ticks noted later in the year. The brown dog tick may be found throughout the dwelling so it is necessary to examine the building throughly and treat all infested areas with an appropriate insecticide formulation. Baseboards, floor and wall crevices, window frames and other harborage sites should be treated with an insecticide spray or dust. Careful attention must also be given to treating the dog's sleeping quarters, bedding, and the dog itself. Suitable concentrations of effective insecticide dusts are available in several brands of dog tick powders. With severe infestations, it may be necessary to retreat both the premises and the dog one or more times at weekly intervals.



SELF-HELP QUESTIONS ON OTHER ARTHROPODS

Now that you have studied the section, answer these questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if you are correct by checking them in the text. Erase your answer and write in the correct answer if your first answer is wrong.

1. What are some species of mites that can annoy man?

2. What stage of the chigger attacks man?

3. What two dangerous spiders are found in Michigan?

4. What disease is transmitted by the American dog tick?

SWIMMERS' ITCH PARASITE AND SNAIL HOST

Swimmers' itch is caused by tiny cercariae, one-thirty seconds of an inch long, penetrating onto the skin of a human. Cercariae are free-swimming larvae an intermediate, stage in the life cycle of blood flukes. The adult blood flukes, called schistosomes, live as parasites in the tissues of mammals and birds, usually those associated with ponds, lakes, and streams. The cercariae of about twenty different kinds of schistosomes are known to penetrate the skin of man and produce a rash. Complete life histories are unknown for many of these different kinds. The typical cycle of the species which causes the majority of itch cases at Michigan swimming areas involves water birds and snails.

LIFE HISTORY

The adult fluke, a very small worm lives as a parasite in the tissues of a suitable host, particularly certain waterfowl. Eggs from the parasite are passed into the water with droppings of the bird. A single, very tiny swimming form called a miracidium is produced from each egg that hatches. These miracidia swim and drift about in search of particular kinds of snails. If the miracidia cannot find a suitable species in a few hours, they will die. However, if they locate a suitable snail, they penetrate into the body through the soft parts. Inside the snail the miracidium undergoes changes which finally result in the production and release of many cercariae. This state of the parasite life cycle may b e seen by placing an infected host snail in a small jar filled with water. After an interval of several hours cercariae shed by the snail will appear as small moving specks in the water. The cercariae swim freely and drift about, waiting for suitable final hosts such as certain species of ducks to come close enough for them to make contact. Few cercariae live much longer than 48 hours. On finding a proper host the cercariae penetrate through the skin, enter the blood stream and develop into adult blood flukes, thus completing the life cycle.

EFFECTS UPON HUMANS

When cercariae accidentally come in contact with an animal which is an unsuitable host, such as humans, they may penetrate into, but not through the skin. The cercariae die within 24 hours after penetration. The body's reaction (allergic) to these organisms (foreign protein) may cause severe itching at each point of entrance. As the cercariae enter the skin a temporary, prickly, itching sensation occurs, sometimes followed by a general inflammation of the area affected. This condition usually subsides quickly, leaving the victim with minute red spots and very little itching. Several hours after penetration intense itching occurs, together with the development of raised red spots similar to pimples. These may become larger and be accompanied by general swelling, especially when aggravated by unrestrained scratching. The victim is usually most uncomfortable during the second, third, and fourth days following exposure. A week after contact all symptoms have normally disappeared except in extreme cases, but small red spots may persist for some time.

SNAIL HOST

The great majority of swimmers' itch problems have been recorded from the inland lakes of the Upper Peninsula and the northern half of the Lower Peninsula. The snails primarily responsible are *Stagnicola emarginata, Lymnaea stagnalis, Physa parkeri* and a small, unknown number of other species in the genus *Physa*.

S. emarginata is the most important host snail because of its broad distribution throughout the northern parts of Michigan and its ability to live in areas preferred by swimmers. This snail occurs commonly on sandy lake bottoms in sunny areas. Their cercariae, released during warm, sunny days in early summer, swarm near the surface in shallow water right along with the bathers. While most snails prefer shorelines protected from the prevailing wind, *S. emarginata* can do well on windswept, exposed shoals with a clean, large gravel bottom free from aquatic vegetation

L. stagnalis is found throughout the range of *S. emarginata*, but seems to prefer weedy areas. Since swimmers normally do not select such places for bathing, contact with cercariae is unlikely. However, cercariae from large

colonies in weedy areas off bathing beaches can cause swimmers' itch from the weed bed to the swimming area during peak cercarial production. This troublesome factor is called cercarial drift.

A third northern species carrying dermatitis-producing cercaria is *Physa parkeri*. Colonies occur in a few of the inland lakes in norther Michigan, but distribution of this species is not general. This snail seems to prefer weedy locations, but can also thrive in clean-bottom areas preferred by swimmers. A few other *Physa sp.* with similar habitat preferences are occasionally responsible.

CONTROL

With our present knowledge of the relationship between schistosome cercariae and snails, it follows that eradication of snails would eliminate the swimmers' itch problem. However, obtaining a total snail kill in a large lake would be a practical impossibility with present control methods. In attempting such an eradication there would also be danger of seriously affecting the fish and fish-food populations. Perhaps in the future small amounts of chemicals specifically toxic to snails may be efficiently and economically used for large-scale treatments. Although research work has been directed toward this goal a universally satisfactory molluscicide has not yet been identified.

Application Methods and Equipment

Treatment methods are normally aimed at getting the chemicals down to the snails on the lake bottom. Best results are achieved by releasing the chemical, normally a heavy granule, under water just above the beach floor. This procedure is usually accomplished with motor-powdered units designed to pump the chemical through flexible tubing which is dragged along the lake bottom as the treatment vessel moves through the infected area. If this type of distribution equipment is not available fair results can be obtained by broadcasting the granules on the water surface and allowing them to sink to the lake bottom.

If application of the necessary chemicals is made at the proper rate, free-swimming fish should not be killed. They will move out of the area. However, since molluscicides currently used in swimmers' itch control are toxic

to fish, treatment should not be made until pan fish and bass are off their beds in shallow water, usually after the middle of June in lower Michigan. Bottom organisms such as leeches, aquatic worms, and insect larvae may also be killed. Some of these animals are used by fish as food, but their loss is unimportant when the whole fish-food producing area of the lake is compared to the treated area. Ratio of untreated area to treated is normally at least 50 to 2.

The snails responsible for the swimmers' itch problem are the ones which need to be controlled. It is better to locate the infected snails before treatment than to chance missing the bed. Pretreatment beach inspection will usually solve this problem.

A large enough area must be treated. Aided by winds and wind-created currents, cercariae may stay together in sufficient numbers to create a swimming beach hazard quite a distance from the snail bed. Treatment of 1,000 feet of lake frontage is recommended as minimum. This usually entails securing permission and the cooperation of several land owners along the shore. Where infected snails are uniformally distributed the area treated should extend from shore to the drop-off. Of course, local conditions will normally determine the actual area to be treated.

Treatment should not be attempted when the lake is rough. The chemical will be dispersed throughout the water by excessive wave action and will drift out of the treatment area rather than remaining on the bottom in the desired location. A little wave action is desirable to aid in distribution, but treatment on a windy day is a waste of time, money, and effort.

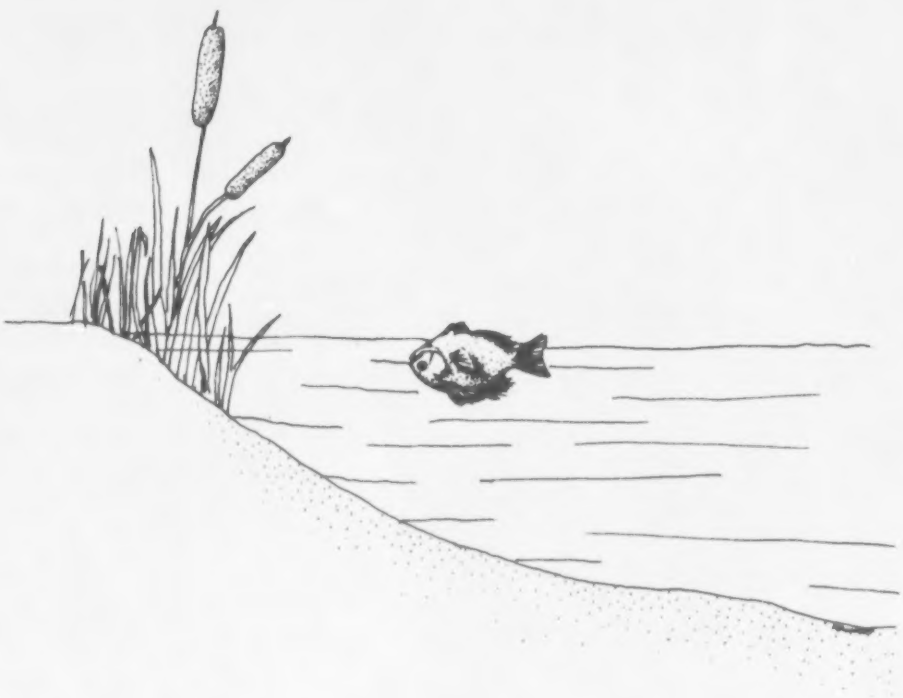
Mark the area to be treated and divide it into small enough plots so that distribution can be even and at the proper rate. Wire-centered plastic clothes line with floats attached every 50 feet is very satisfactory as a marking and measuring device. It is usually best to commence treating next to and parallel with the shore and work towards deeper water.

Precautions

Swimming and the use of motor boats should not be allowed in the area of treatment for 24 hours following chemical application. While there is little

danger to swimmers from the chemicals, safety dictates keeping out of the water for this period. This restriction also prevents the layer of chemicals from being disturbed. Agitation of the water would cause mixing with bottom materials. A subsequent loss in effectiveness would result. There are also indications that dying snails release large numbers of cercariae.

Additionally, fish confined by liveboxes within the treated area will probably be killed. To prevent mortality the fish should be removed and not returned until the applied chemical is no longer toxic.



SELF-HELP QUESTIONS ON OTHER ANTHROPODS

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1. What is the adult stage of swimmers' itch called?

2. What is miracidium?

3. What place do snails have in the life cycle of swimmers' itch?

4. Why do humans react to the penetration of cercaria into the skin?

5. Should chemicals used to control swimmers' itch be applied to the surface or to the bottom of lakes?

6. Swimming and boating in a treated area should not be allowed for how long following treatment?

VERTEBRATE PESTS

BATS

Bats, the only true flying mammals, are associated with fables, superstition and other folklore. From an economic standpoint bats have unsubstantiated value. They are insectivorous, often consuming insects at a rate of one-third to one-half of their body weight per day.

Although we shall be concerned with their control, bats in the natural vironment are remarkable members of the wildlife community and normally should be protected rather than destroyed.

Generalized Life History and Habits

Most bats annually produce a single offspring while a few species have from two to four young each year. Bats give live birth after a varying gestation period. The newborn bat, about one-third the weight of the parent, is sometimes carried by the mother and breast fed until able to seek its own food. Generally, colonial species leave their young in nursery colonies in caves, attics or similar places; while solitary species leave their young hanging in trees among the leaves. Because of their small size and high metabolic rate, bats are sensitive to extremes of temperature. Most species hibernate in constant-temperature caves or buildings or migrate to warm climates in the winter.

Bats' feeding cycle begins at twilight. It is common for all members of a colony to leave the roost at about the same time. They feed for an hour or two and then return to roost. Some feeding may occur throughout the night and by sunrise all bats have returned to their daytime roots.

While certain bats roost singly in places such as trees or rock crevices, other bats live in colonies in buildings, mines or caves. Some prefer cracks or confined spaces between beams or walls; others may be found clustered in dark open spaces such as the roofline of an attic or barn.

Generalized Description

Bats vary in size, color and peculiarities. They have small eyes and apparently poor vision. The ears usually are prominent and have a well-developed

membranous process, the *tragus*, which is an outgrowth from the inner base of the ear. Bats primarily use echo-location (a type of sonar system) to guide themselves in flight. They emit high-pitched squeaks from their mouth which are reflected back from objects in their path and are picked up by their ears. The wings consist of soft and generally naked skin connecting the sides of the body, the large front limbs, the four elongated fingers and the small hind legs. The clawed thumbs are separte. Similar membranous skin joins the hind legs with the tail in most U. S. species. The hind legs with their five toes are turned outward, directing the knee backward and serving as support for the wings.

Identification

There are three general groups of bats in the United States. These are the leaf-nosed bats, free-tailed bats and evening bats. All belong to the order Chiroptera.

American leaf-nosed bats are primarily tropical, but one species inhabits the Southwest. It has a leaflike nose appendage, medium-size body and foot-wide wingspan. These bats are seldom a problem in the United States.

Free-tailed bats, found in California and the Southwest, are characterized by the tail extending beyond the membrane between the back legs. Their flight is erratic and rapid. Two species of free-tailed bats are found in the United States.

1. The *California mastiff bat*, the largest United States bat, roosts in buildings. Its ears flop over the face making identification simple.
2. The *free-tailed bat* is found commonly in the Carlsbad Caverns. It also inhabits darkened buildings, attics, and corners of structures in Texas, New Mexico, Arizona and some contiguous states. In certain areas, this species has been demonstrated to be seriously infected with rabies.
3. Evening bats are the most widespread, numerous and diverse group of bats in the United States. They often resemble mice in size

and color, although some bats are quite striking in appearance. The Appendix shows their distribution in the United States and relative importance to PCO's. Some species of the little brown bat, big brown bat, and Pipistrelle cause the most frequent problems for the PCO and have caused the majority of human exposures to known rabid bats. Those species that are infrequently encountered can be disregarded as a health threat, leaving them only as an occasional nuisance problem. Care should be exercised, particularly in identification, to protect certain certain species of *Myotis (M. grisescens and M. sodalis)*, since these animals are listed as rare and endangered species under the Federal Endangered Species Act of 1973.

1. The little brown bat (*Myotis spp.*) weighs approximately one-fourth of an ounce, has small roundish ears and a wingspread of about ten inches (see Appendix). These bats live in caves, barns, attics and trees. They occasionally fly during the daytime, but are most active during the night. The females produce a single offspring between mid-June and mid-July. The young are not carried on flights as in other species, but are left hanging in daytime roosts.

2. The Pipistrelle (*Pipistrellus spp.*) bats are the smallest bats in the United States. They roost in caves and produce one to two young in June or July. Feeding flights occur early in the morning or late in the evening. These bats spend the winter on the roofs of caves, hibernating singly or with a few individuals of the same species.

The bite of both little brown bats and Pipistrelle bats seldom pierces the skin; thus, the potential for rabies transmission in these species is low.

3. The big brown bat (*Eptesicus fuscus*) is the largest bat of these three groups (see Appendix). Its wingspread is about ten inches and it weighs approximately two-thirds of an ounce. These bats spend the day usually in clusters in caves, hollow trees or attics and other parts of buildings.

Bats are difficult to identify and even experts have trouble identifying some species. Contact the wildlife department of your state university, health department, or fish and wildlife personnel when help in identification is needed.

Bat Droppings

The presence of bats often may be recognized by accumulations of droppings at or near roosting sites. These deposits have added significance because of certain diseases (see discussion below), objectionable odors and stains and attraction of certain insects that develop in this organic matter.

Care should be exercised so as not to confuse bat droppings with those of mice or other small rodents. Generally, dry bat droppings easily crush into fine fragments, whereas mouse droppings are firm and do not readily fragment. Bat droppings will usually contain insect parts because of their insectivorous habits.

Diseases Transmitted by Bats

Rabies: While only a small percentage of bats are infected with rabies, any bat should be looked upon as potentially dangerous and should be approached with caution. Rabies can occur in bats without them showing symptoms. Hard hats, heavy leather gloves and coveralls should always be worn during any bat control effort, including inspections. Suspect a bat of carrying rabies if you see any of the following symptoms:

1. Bats attacking other bats
2. Bats flapping wings on the ground or on low objects
3. Bats appearing to be sick, weak or paralyzed
4. An unusual number of dead bats in a localized area
5. Frequent daytime exposure
6. Erratic flights together with frequent lighting on surfaces

NPCA recommends you contact your state public health department when any of the above behavioral symptoms are observed. It is often necessary to capture alive those suspected animals so that they may be tested for rabies infection. If at all possible, capturing specimens should be done by, or in cooperation with, public health personnel. If rabies has been confirmed in a bat population, control should never be attempted without supervision of the public health department. Any bat causing a bite should be captured with brain intact for examination by health authorities.

Histoplasmosis: Accumulations of bat droppings in attics or soil create an environment suitable to the growth of *Histoplasmosis capsulatum*, a fungal organism producing a severe lung infection often fatal to man, and apparently dogs, cats and other animals as well. The fungus is present in droppings; therefore, a large established bat roost in an attic or cave can be dangerous, since fungal spores are drawn into the lungs when breathing the dust in the roosting areas.

Public health officials working around accumulations of bat droppings should wear coveralls, gloves, caps and dust-proof respirators. It is important that the respirators fit properly and are approved by the National Institute for Occupational Safety and Health (NIOSH) for nuisance dusts.

Personal hygiene is particularly important for those working in areas contaminated by droppings or dust from bats. Contaminated clothing should be changed at the completion of the work, followed by thorough bathing.

Listeriosis: Bats are suspected of transmitting listeriosis: however, the incidence of transmission or actual infection in humans is low. The causal organism, a bacteria, elicits symptoms resembling certain forms of encephalitis.

Venezuelan equine encephalitis (VEE), eastern equine encephalitis (EEE), western equine encephalitis (WEE), St Louis encephalitis (SLE). Bats harbor mites and are attacked by mosquitoes which are carriers of encephalitis VEE, EEE, WEE and SLE. These virus-caused encephalitis diseases can be fatal to humans, and those who recover are sometimes permanently impaired. PCO's involved in bat control should use extreme caution, particularly at times when VEE, EEE, WEE or SLE outbreaks or epidemics have been reported in their areas.

Ectoparasites: External parasites that attack bats include several species of mites, ticks, fleas, parasitic flies and bat bugs. These ectoparasites (excluding parasitic flies) may attack other animals and man, particularly when bats are infesting a place of human habitation. Pest control operators attempting to remove or control bats also are subject to their attack; therefore, the use of an insect repellent on clothing is strongly encouraged. Control of ectoparasites must accompany any bat control effort.

Control

Bat control should only be accomplished by thorough planning an understanding of such factors as identification, habits, disease, ectoparasites and population size. At present, no chemical is registered specifically for bat control. This situation dictates the use of alternative methods where available and the use of chemicals to alleviate problems created by bat infestations—odor, ectoparasites, droppings.

Some commonly occurring problems associated with bats are presented together with recommended general control procedures. Other situations may arise, however these control procedures may be employed to fit each situation.

1. Problem: Bats may enter a house at night through open doors or windows searching for flying insects. If chimneys are used by bats for summer roosts, the young may fall or blunder into the house through the damper when they are learning to fly. Parents may follow, resulting in one or more bats flying around inside a house.

Control: Physically removing the bats is the best procedure. First locate openings where bats may have entered and recommend that they be closed or screened off.

If the bats are clinging to walls or ceilings, collect them with a fish landing net. They can be released outdoors without harm. Where it has been determined that killing bats is the safest method of removal a mouse snap-trap attached to a long handle may be used. A bat also can be hit with any solid object if it is not in flight.

If bats are actively flying about the house during the daytime, open all windows and doors. The bats will detect the fresh air movement and fly out. Capturing or killing a bat in flight can be accomplished using a fish landing net or a tennis racket. A bat's echo-location system makes a broom or other solid object ineffective.

2. Problem: You may find bats roosting under the eaves of buildings or on other areas outside the structure.

   Control: Explain to the customer that this is usually a temporary roosting place since most bats prefer areas that are warm at night. Control is usually not necessary unless droppings become a problem. If bats continue to return, eaves or other roosting areas can be sprayed with a strong stream of water.

3. Problem: Bats are found roosting inside a structure (house, school, warehouse). This problem was detected when the customer began to smell a strong pungent odor later identified as bat urine and droppings.

   Control: You must first determine whether the potential for disease exists or whether the roost is simply a nuisance. (See section on Diseases Transmitted by Bats.) If you have reason to suspect that rabies is endemic in the bat population, you immediately should contact your local or state public health department.

4. Problem: Bats may be present at night around lighted outdoor swimming pools and patio porches, both of which attract night-flying insects which are prime targets for bats.

   Control: The objective becomes one of educating the people to alter their habits to avoid attracting bats -- in this case, to turn off lights at night or use lights less attractive to insects.

5. Problem: Bats roosting in food warehouses. Bats droppings are considered a food contaminant by FDA and USDA.

   Control: In a large space such as a food warehouse bats will not roost in the same exact place each night. Droppings directly below bat roosts will indicate the probable roosting vicinity. After removal of all bats and droppings, all openings must be closed with metal sheeting, wood, fiberglass, or steel wool to prevent a reinfestation.

Chemical control: After the presence of rabies has been established, state public health officials can apply to the Environmental Protection Agency for permission to use DDT or other control agents. Section 18 of the Federal Insecticide, Fungicide and Rodenticide Act, as amended, provides the exemption to the DDT ban when a significant public health problem exists. Applications of DDT must be made under the direction and supervision of the state health agency.

DDT must be applied in an aerosolized form—dust, mist or fog—so that it is taken in via the pulmonary route. Water or oil-based spray formulations of DDT sometimes require up to six weeks for mortality to occur, allowing infected bats to disperse.

When existing labels permit, fumigants may be used to quickly eliminate bats in an enclosed area. This method of control should always be approached with extreme caution and only when disease control is a paramount consideration. Make sure all local ordinances and safety precautions concerning the use of fumigants are allowed.

After control has been completed, deposits of droppings and dead bats should be removed for the following reasons:

1. To prevent the occurrence of histoplasmosis of other diseases associated with bat droppings.
2. To eliminate odor and staining problems from droppings.
3. To eliminate the odor of dead bats and the likely insect problems associated with decaying carcasses.
4. To prevent the buildup of insects that develop in organic matter.

Great care must be exercised during these clean-up operations regarding personal protection (see section on disease transmission). Dead bats never should be handled without using gloves and preferably tongs or heavy forceps. After a thorough cleaning, the area should be sprayed with a 10 percent formalin solution.

Repellents: Materials such as paradichlorobenzene or naphthalene (moth flakes) liberally applied may be used to repel bats from attics or other roosting areas when disease is not a problem. Dosages of five to ten pounds per average attic offer only temporary control and should be used in conjunction with other measures such as batproofing. Glass fiber insulation material blown into spaces occupied by bats will repel them. However, problems do exist with the use of repellents:

1. Odors may be objectionable to occupants of treated structures.
2. Repellent materials to date are not labeled for bat control. However, if droppings are located, paradichlorobenzene or naphthalene may be applied to camouflage odors with repellency as a side benefit.

Batproofing: Batproofing should be the first consideration in bat control where labor costs and building construction encourage tight buildings; however, slate roofs and other similar kinds of construction and building renovation costs associated with closing all openings more than one-fourth inch in diameter make batproofing generally impractical.

Batproofing is often necessary following the use of fumigants which have no residual qualities. If batproofing can be accomplished, walls, roofs and floors should have no openings larger than one-fourth inch in diameter. Roosts on the outside of buildings should be eliminated. Completion of proofing should find all of the bats trapped outside. Close all but a few main entrances, wait four days to accustom the bats to leaving by these; then, in the evening after all the bats have swarmed out, close the remaining openings. The structure should be checked for several everings. If bats are present, the remaining openings must be found and closed. Batproofing is best done in early spring and fall. At other times young bats may accumulate on the ground near roosts or be trapped inside to decay and produce odor.

Ectoparasite control: The control of ectoparasites should be part of all bat control jobs by killing those that may remain and try to migrate. Materials such as lindane, malathion, Vapona and diazinon are useful and effective, but may not be labeled specifically for bat ectoparasites or several of the species of mites, ticks, fleas or bat bugs that infest bats. Select a product label specifying at least one of the ectoparasites; control of others present will be incidental.

Lindane in oil and certain formulations of Vapona are highly repellent to bats, but Vapona has no residual effectiveness.

TABLE 2. EVENING BATS OF THE UNITED STATES (*VESPERTILIONIDAE*)

Common Name	Genus Name	Life Style	Area of Country	Problem Status
Little Brown Bat	Myotis 20 spp.	Colonial*	Everywhere	Frequent
Big Brown Bat	Eptesicus fuscus	Varied	Everywhere	Frequent
Pipistrelle	Pipistrellus 2 spp.	Varied	Mostly Western, East & South	Frequent
Red Bat/ Hoary Bat	Lasiurus 2 spp.	Solitary	Tree Bats	Infrequent

TABLE 2 (Continued)

Yellow Bat	Dasypterus 2 spp	Varied	S.E. U.S.	Infrequent
Silver-haired bat	Lasionycteris 1 spp.	Solitary	Universal	Rare
Rafinesque	Nycticeius 1 spp.	Solitary	S.E. U.S.	Rare
Lump-nosed Bat	Corynorhinus 2 spp.	Colonial	S.E. & Western, U.S.	Rare
Pallid Bat	Antrozous 1 spp.	Colonial	Western U.S.	Rare
Spotted Bat	Euderma 1 spp.	Solitary	S.W. U.S.	Never

*Certain species, others solitary. Some species will colonize during winter under certain conditions, but assume solitary habits at other times.

THE NORWAY RAT

THE NORWAY RAT

Rats and mice have accompanied man to most of the areas of the world that he has settled. Historically, they have been responsible for more human illnesses and deaths than any other group of mammals. Man's indifference and carelessness in handling food and refuse have fostered populations of rats and mice in such close proximity to his home and work that they are commonly called "domestic" rodents.

Economic Importance

Rats in the human environment cause enormous annual economic loss. They consume or contaminate vast quantities of food and feed and destroy other property, as, for example, when they cause fires by gnawing the insulation from electric wires. It is estimated that 5 to 25 percent of fires of unknown origin on farms are caused by rats.

No reliable estimate of the rat population of the United States is available as a basis for calculating these losses, although the figure of one rat for every person has frequently been quoted in the literature. If, in consideration of recent improvements in environmental sanitation and rodent control, this rough estimate used in the past is reduced by one-half, that is, to an estimated one rat for each two people, then the United States has some 100 million rats. Each rat damages between $1 and $10 worth of food and other materials per year by gnawing and feeding, and contaminates 5 to 10 times more. Thus, rats may cost the United States between $500 million and $1 billion annually in terms of direct economic losses.

Rat Bites

In addition to the annual dollar losses due to rats, there is also the intangible cost of rat-associated injury and illness. Rat bites create a serious health problem and are far more common than most people realize. In some of the larger cities, hundreds of rat bites are reported each year, and certainly there are many cases that are never reported.

Based upon available records, large metropolitan areas of the United States experience rat bite at the rate of approximately 10 per 100,000 persons per year. This amounts to 3,000 to 4,000 cases annually just in the large cities alone,

and the cases unreported bites from them and from the smaller cities and towns undoubtedly total several thousand more.

Helpless infants and defenseless adults (invalids or unconscious persons) are particularly subject to attack by rats. Occasionally rat bite wounds cause death. Therefore, all bites must be carefully disinfected at once to prevent secondary infection, and the patient then referred to a doctor for prompt emergency treatment.

Rat-Borne Diseases

Rats are responsible for the spread of a number of diseases, either directly, as by contamination of human food with their urine or feces, or indirectly, by way of rodent fleas and mites. Following are brief descriptions of the more common of these diseases:

Leptospirosis: (Weil's disease)—causative agent, "Leptospira spp.," primarily "L. icterohemorrhagiae": Leptospirosis is a mild to severe infection that is seldom fatal. Human cases of the disease result from direct or indirect contact with infected urine of rodents and of certain other animals. The spirochetes, which are found in water or on food, may enter through mucous membranes or minute cuts or abrasions of the skin. Thus, Weil's disease is often found in sailors, miners, sewer workers, fish or poultry dealers, and abbatoir workers. In a recent study in Hawaii, Norway rats and house mice were found to have high *Leptospira* carrier rates.

Salmonellosis—causative agent, "Salmonella spp": Salmonellosis, which is generally classed as food poisoning, is a common disease of worldwide distribution. It is an acute gastroenteritis produced by Salmonella bacteria of the group pathogenic for man and other animals. It is spread in various ways, one way being through food contaminated with rat and mouse feces containing Salmonella organisms.

Trichinosis—causative agent, "trichinells spiralis": Trichinosis results from an infestation of the intestines and muscles by larvae and cysts of *Trichinella spiralis*. Both man and rodents develop the disease from eating raw

or insufficiently cooked pork infected with the organisms. Research has indicated that rodents may play an important role in the spread of the disease to hogs permitted to feed on uncooked garbage at open dumps, for hogs experimentally fed the trichina-infected feces of rats and mice readily became infected. In turn, the rodents at open dumps undoubtedly often feed on raw or insufficiently cooked pork scraps, which keep the rodent-swine-man cycle of this disease going.

Murine-typhus fever—causative agent, "Rickettsia typhi": Murine typhus is distributed throughout the southeastern and Gulf Coast states but has not been reported in Michigan. Rats are the reservoir animals from which the disease reaches man by way of rat fleas. The oriental rat flea, *Xenopsylla cheopis*, is considered the most important vector of the disease. The causative organism enters the bloodstream when feces of infected fleas are scratched or rubbed into a flea-bite wound or other break in the skin. Murine typhus is similar to epidemic or louse-borne typhus, but illness is much milder and the fatality rate in untreated cases is much lower.

Plague—causative agent, "Pasteurella pestis": Plague is the "Black Death" that once killed millions of people in Europe, Asia, and Africa. No serious outbreaks of plague have occurred in the United States since 1924. However, a reservoir of the disease exists in wild rodents of the western states, where the bacteria are transmitted from one rodent to another and sometimes to man by the bite of rodent fleas. There is always the danger that domestic rodents will become infected, and that they, in turn, will carry the infection to human population centers. The disease is often fatal to the rat and the flea, and the death rate in untreated human cases is extremely high.

Habits and Characteristics

The Norway rat (*Rattus norvegicus*), predominantly a burrowing rodent, is the most common and the largest of the domestic rats. It is distributed generally throughout the temperate regions of the world, including the United States.

Common names for the species are the brown rat, the house rat, the barn rat, the sewer rat and the wharf rat.

- Adult weight: 16 or more ounces; adults average about a pound.
- Fur: Coarse, generally reddish brown, with many variations.
- Body: Heavyset, and with muzzle blunt.
- Tail: Bicolored, shorter than body and head combined.
- Ears: Small, close-set.
- Droppings: Large (up to three-fourths inch long), capsule-shaped.
- Sexual maturity: Attained in 3 to 5 months.
- Gestation period: Averages 22 days.
- Young: Average 8 to 12 per litter.
- Number of litters: Averages 4 to 7 per year.
- Number weaned: Averages about 20 young per year per female.
- Length of life: Averages about 1 year.
- Harborage: Outdoors—in burrows in the ground and under foundations of buildings, and in rubbish dumps; indoors—between floors and walls, in enclosed spaces of cabinets, shelving, and appliances, in piles of rubbish, and in any other space concealed from view.
- Range: Frequently 100 to 150 feet.
- Food and water: Omnivorous; garbage, meat, fish and cereal baits are well accepted; daily requirement is three-fourths to 1 ounce of dry food, one-half to 1 ounce of water.
- Touch: Well developed in highly sensitive whiskers or vibrissae, and certain guard (tactile) hairs. Rats prefer to run along walls or between things where they can keep their whiskers in contact with side surfaces.

- Vision: Not too well developed. Apparently they are color-blind, so any distinctive coloring of poison baits does not reduce their acceptance to rats.
- Smell: Keen. Rats apparently like the odors of most foods eaten by man. They are used to the odor of man, so his odor on baits and traps does not repel them.
- Taste: Not as sensitive as in man. Rats associate sickness caused by poison bait with the bait and not the poison. They prefer fresh food to decayed food.
- Hearing: A keen sense of hearing. They can locate the source of a noise within 6 inches. Loud noises cause rodents to attempt escape.
- Balance: Excellent. A falling rat always lands on its feet. The roof rat even maintains its balance well while walking on suspended wires.
- Reaction to strange objects: Rats may avoid a new sound or a strange object in their environment for three or more days, particularly if their associates are alarmed by it. Other objects are readily accepted by them (examples—food, garbage). As rodent population pressures build, the rats frequently exhibit "chain-fright reaction" to disturbances.
- Climbing: The Norway rat can climb quite well when necessary.
- Jumping and reaching: Rats can jump nearly 2 feet vertically, 3 feet with a running start; they can jump 4 feet horizontally, and 8 feet from an elevation that is 15 feet above the finish point. Rats can reach upward about 18 inches.
- Swimming: Rats are good swimmers. They are able to swim up through floor drains and toilet-bowl traps.

Rat sign: Rats are habitually nocturnal and secretive and are rarely seen during the day except when infestations are heavy. Therefore, it is necessary to interpret signs of their activities properly in order to plan control work. These signs are found in secluded places, such as along walls, under piles of rubbish, and behind or under piles of rubbish, and behind or under boxes, boards, and thick vegetation. From the signs, one can tell the species present, and whether a rat infestation is current or old, heavy or light.

Droppings: Fresh droppings of feces are usually moist, soft, shiny, and dark, but in a few days they become dry and hard. Old droppings are dull and grayish and crumble when pressed with a stick.

Runways: Rats habitually use the same runways between food, water, and harborage. Because of the keenly developed sense of touch in their vibrissae (whiskers) and in specialized hairs along the body, rats prefer continual body contact with at least one vertical surface, such as a fence or wall. Outdoors these runways are narrow pathways of beaten earth swept clear of debris. Indoors, greasy runways are found along walls, steps, and rafters. Undisturbed cobwebs and dust in a runway indicate that it is not in use.

Rub marks: Along regularly traveled runways, a dark, greasy mark forms from contact by the rodent's body. Fresh marks are soft and will smear if rubbed. As the grease ages, it dries and gathers dust and will flake off when scratched with a fingernail. The rubmarks of the Norway rat are most commonly found along runways near ground or floor level, while those made by the roof rat are most commonly seen overhead as swing marks beneath beams or rafters at the point where they connect to the walls. Mice do not leave detectable rubmarks except when the infestation is heavy.

Burrows: The Norway rat prefers burrows for nesting and harborage; the roof rat burrows only occasionally. Burrows are found in earth banks, along walls, under rubbish or concrete slabs, and in similar places. If a burrow is in use, its entrance will be free of cobwebs and dust. Fresh rubmarks on hardpacked soil at the opening indicate a well established and presently used burrow. The presence of fresh fragments of food or freshly dug

earth at the burrow entrances also indicates current use by rats.

Gnawings: The incisor teeth of rats grow 4 to 5 inches a year, so these rodents must do some gnawing each day in order to keep their teeth sharp enough to use. Rats also gnaw to gain entrance and to obtain food. When gnawings in wood are fresh, they are light colored and show distinct teeth marks. Small chips of wood or other materials indicate recent gnawing. With age, wood gnawings become dark and smooth from weathering and from frequent contact with the rodent's body.

Tracks: Fresh tracks are sharp and distinct, whereas old tracks are covered with dust and are therefore less distinct. The tracks of the 5-toed rear paws are more commonly observed than are those of the 4-toed front paws, but both may be present. Smooth tracking patches of any dust material, such as flour or talc, placed along runways are of value in checking for rodent activity. To see tracks in the dust, the inspector should hold a flashlight at an angle that causes the tracks to cast distinct shadows. Tail marks, too, are often visible in dust or tracking patches.

Control

General: Controlling rat populations, not individual rats, is the key to a successful rodent-control program in a community. Examples of populations are the rats within a city block, those in a sewer, the rats infesting a farm, or those living in or around a feed mill. At any given time, each city block has a certain capacity to support rats. This capacity is related to the availability of food, harborage, living space and other vital rodent requirements. The rat population in a block cannot long be greater than this capacity. Permanent reduction of one or more vital factors (food, water, or harborage) in the block will result in a permanent reduction in the rodent population.

Forces that determine the size of a rodent population at a given time are: reproduction, mortality, and movements into or out of an area. Reproduction tends to increase a population, mortality to decrease it, and movements can work either way. Rats breed during the entire year, with peaks in spring and fall.

Winter is the best time to conduct a poisoning campaign on a rat population, since breeding is then at a minimum. The next best times are summer, then fall. In field tests, populations poisoned in the winter took 12 months to return to normal; those poisoned in summer, only 6 months.

As rat and mouse populations increase in size, the mortality rate also increases until a state of equilibrium is reached. Increased competition due to population pressure increases the mortality and movements of rodents. Movements into or out of an area are less important in determining the size of rat populations than either reproduction or mortality. Rodents often migrate much greater distances than the limits of their normal home range (rats 100 to 150 feet, mice 10 to 30 feet) as, for example, their annual movement from fields to buildings in the fall and then back to the fields in the spring; and their migrations when their usual sources of food are cut off, or when they are flooded out or burned out.

The limiting factors that control the balance of reproduction, mortality and movement of rodents are: the physical environment, predation and parasitism, and competition.

The physical environment is comprised of three main elements: (1) food and water, (2) harborage, and (3) climate. Improperly handled foods, garbage, and field crops are the major sources of rodent food. Climate directly affects the number of rodents able to survive outdoors but has little or no effect on those living in heated buildings. A given environment can support only a certain number of animals. Generally speaking, areas with warm, moist climates are favorable, while those with dry, cold climates are unfavorable. Man can reduce rodent populations and keep them low by permanently eliminating their food, water, and harborage.

The effect of predators and parasites on reduction of rodent populations appears to be temporary. This includes the predatory activities of man, dogs, cats, foxes, rats, birds, snakes and other foes, and the parasitic activities of bacteria, rickettsia, spirochetes, protozoa, and worms.

Competition, whether between members of the same species or betweeen two or more species, is one of the most important factors limiting rat populations. Norway rats compete intensely with roof rats and have replaced them over large areas, particularly in many cities where both once were found. Competition among members of the same species is very closely associated with the social organization of a population. A definite social order, or hierarchy, exists among rats and mice. This social order is determined largely by fighting, and the most aggressive animals in a population are dominant. Others are killed or are forced to move, and those that move may suffer even higher mortality from predators and resident rodents in the new areas. The strife caused by increased population pressure lowers reproduction, increases mortality, and decreases the population.

In summary, the most lasting control can be achieved by permanent alterations of the physical environment of rats and mice. Man should so change the environment as to cause increased competition and predation, thereby lowering the capacity of the environment to support rats and mice. Environmental sanitation is thus the first and foremost requirement for permanent rodent control.

Sanitation: Poor storage of refuse (garbage and rubbish) and of food in the home and in business establishments invites rats to infest blocks and neighborhoods. Rat and mouse populations are controlled by the storage of all refuse in rodentproof containers, the satisfactory collection and disposal of refuse, and the proper storage of usable materials. Structural harborage, such as small protected enclosures under cabinets, shelves, and stairs, should be eliminated. Permanent removal of harborage and sources of food will eliminate existing rat and mouse populations.

Refuse storage facilities should include enough containers to hold all garbage and rubbish that normally accumulates between collection days. A good refuse container should be:

1. Rust-resistant
2. Water-tight
3. Tightly covered
4. Easy to clean

5. Provided with two handles or a bail

6. Of rat- and damage-resistant construction (heavy-duty)

7. Designed with a recessed bottom

Recommended container capacity is: for garbage only, 5 to 12 gallons; for combined garbage and rubbish, 20 to 32 gallons.

Fifty-five gallon drums should not be used for refuse containers. When filled they are too heavy and too clumsy to handle, and they either have no lids or the lids are unsatisfactory.

Recently, units using suspended disposable paper bags to contain refuse have been tested in various communities. Advantages claimed are improved sanitation, reduced collection costs, and improved appearance.

Some communities have inaugurated refuse collection systems utilizing ratproof storage containers with a capacity of several cubic yards each. These containers are regularly emptied into a large compactor vehicle, which transports the refuse from several containers to a sanitary landfill or an incinerator. They are available in various sizes appropriate for use in markets, apartments, schools, and other large food-handling establishments. Some of the larger units are equipped with mechanical compactors to reduce the volume of refuse and thereby increase their capacity. A special truck is required for servicing these units mechanically. After each collection, the containers should be washed or steam cleaned to avoid fly and odor problems.

Draining and wrapping household garbage before placing it in the refuse container:

1. Reduces fly breeding

2. Reduces odors

3. Prevents garbage from sticking or freezing to the sides of the container, thus avoiding damage to cans (from bumping to loosen garbage)

4. Reduces cleaning frequency

5. Adds to the useful life of the container.

The practice of wrapping garbage is not practical for all food-handling establishments. However, special low-cost, waterproof garbage bags designed to fit standard-size containers are available commercially.

Proper storage of usable materials reduces the food and harborage available to rodents to a minimum. All packaged bulk foodstuffs should be stacked 12 to 18 inches off the floor. Unless used promptly, foods removed from commercial packaging should be stored in covered glass or metal containers. All food scraps left after meals should be collected and placed in a covered refuse container.

Sweeping floors at frequent intervals removes rodent food and permits ready detection of fresh rodent signs. In food handling locations, a white band 6 inches wide painted along the floor next to the wall speeds the discovery of rodent droppings, rodent tracks, and other signs indicating the presence of rats and mice.

Thorough inspections should be made regularly to detect any new evidence of rodent infestation. Remember, effective and permanent control of rats and mice can be attained only through a continuous sanitation program.

Good refuse storage practices are dependent upon efficient refuse collection service. Twice-weekly collection of residential garbage, or of combined garbage and rubbish, is recommended to prevent the overloading of individual storage facilities, which provide exposed food for rats and a breeding medium for flies. Daily collection of refuse is recommended for business sections.

Four garbage storage and collection systems were studied in California, and the percentages of containers producing excessive numbers of flies were found to be as follows: 67 percent, with metal cans and once-a-week collection; 25 percent, with disposable paper bags and once-a-week collection; 10 percent, with metal cans and twice-a-week collection; and almost no fly production with disposable bags and twice-a-week collection. An economic evaluation of these systems, based on a time-and-motion study of pickup service in four comparable areas, showed a manpower savings of up to 30 percent when paper bags were substituted for metal cans. However, unless the collection system is actually designed around the concept of paper bags, the savings in time does not equal the cost of the paper bags.

Compactor-type trucks are the equipment of choice for collection, because they (1) handle bigger loads, (2) prevent contents from blowing or spilling out, (3) are leakproof, and (4) have low loading heights.

Open refuse dumps and areas where hogs are fed on garbage are major producers of flies and rats, and the rats may migrate from these unsatisfactory disposal sites to adjacent cities and farms. When the rats' daily source of food at such a site is cut off, as by a snowstorm or a refuse collectors' strike, great numbers of the rodents will migrate elsewhere. Unfortunately, many cities have unsanitary rat-infested dumps. Until a sanitary method of disposal is instituted, it is often necessary to poison rats periodically to reduce the population and to prevent migrations.

The sanitary landfill and incinerator methods of refuse disposal can be operated so that conditions favorable to rat production do not develop. At a properly operated sanitary landfill, garbage and rubbish are compacted and covered with earth daily. Local officials must demonstrate continuing interest in and support of a model operation by providing adequate financing, by visiting it frequently and by making it a showplace for visiting officials. Modern incinerators operating at high temperatures completely burn confined refuse, thus leaving a residue that does not furnish food for rats.

Where sewer systems are adequate, electric garbage grinders provide sanitary disposal of garbage. However, this leaves other rubbish, such as cans and bottles, which must be collected regularly.

Research has shown that composting municipal wastes is feasible and that it can meet public health requirements for sanitary disposal. Costs of composting are higher than with the sanitary landfill, but lower than with the incinerator operation. Composting permits the salvage of some noncompostible materials such as metals and rags, and produces an end product, humus, that can be sold as a soil-conditioner supplement to fertilizers. However, composting should be considered primarily as a method of sanitary refuse disposal rather than as a source of income or a method of satisfying an agricultural need. Despite considerable investment and the application of advanced techniques, no large-scale composting plant has operated economically for a long enough time to indicate success.

Rats often enter sewers at outlets and through manholes, catch basins, broken pipes, or drains. They nest in earth at or near such locations. In the sewers, the rats feed on floating organic matter or that stranded or adhering to the bottom or sides of pipes, especially during periods of low sewage flow. The problem is usually greatest where storm and sanitary sewers are combined. The domestic sewage of an average community furnishes ample food for sizable rat populations. The problem of rats in sewers will probably become greater in this country as the expanding use of garbage grinders increase the food content of inadequate sewers.

In the community rodent-control program, rodent killing is an important adjunct to improvements in sanitation and other environmental factors. However, timing is of great importance, and control through killing alone does not endure. For these reasons, killing methods can be applied most effectively:

- BEFORE sanitation or cleanup programs are begun—to prevent mass movement and spread of rodents.
- AFTER dusting with 10 percent DDT or other recommended insecticide for flea control—to suppress plague and murine typhus by reducing rodent populations.
- AFTER ratproofing work—to eradicate rodents in buildings.
- EARLY in community programs—to stimulate public interest in rodent control.

Rat killing without environmental improvements, particularly good sanitation, is ineffective because:

- Rats and mice rapidly regain the original population level through their high birth rate and the greater survival of young as a result of less competition.
- A continuous killing program is necessary, which is costly in terms of labor and materials.
- Continued use of most poisons can result in bait shyness.

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Ectoparasite control: Control of ectoparasites (fleas, lice, mites, and ticks) is vital in order to prevent transfer of rodent diseases to man. Ectoparasites feed on the blood of their rodent hosts and may thereby become infected. When such hosts are killed through trapping or poisoning, their ectoparasites may, by chance, select man as a temporary host, and if they are diseased, may infect him with the organisms. When disease is thought to be present in a population of rodents, the ectoparasites must be killed before rodent eradication measures are begun.

To treat a building or an area for control of ectoparasites:

1. Inspect for signs of rat or mouse activity, especially for rubmarks at the base of walls, and for evidence of runways and burrows.
2. Treat all runways, burrow entrances, and nests with recommended insecticide dust. Dust the vertical surfaces against which the rodents may brush by using a dust gun, hand shaker, or scoop, or by hand throwing the insecticide.

Rats that come in contact with insecticide dust carry it on their feet and fur to their burrows and nests. This gives ectoparasite control in areas beyond the reach of normal dusting activities.

Carcass disposal: The carcasses of all rats recovered from poisoning, trapping, and gassing operations should be buried or burned. Anyone handling the dead rodents should wear rubber gloves.

Ratproofing: Ratproofing or vent stoppage consists of changing structural details to prevent entry of rodents into buildings. Openings as small as a half inch will admit young rats. Where only Norway rats are encountered, such openings as ground floor windows, sidewalk gratings, basement vents, utility pipe openings, and foundation walls are normally ratproofed; but where roof rats are found, ratproofing must also include wires, vertical pipes, and openings to upper floors and roofs. Where only Norway rats are encountered, the stoppage work, in order to be economically feasible, is confined to the more likely points of entry and not to every possible entrance.

The cuff and channel for wooden doors to side and back entrances prevent rats from gnawing under or around the doors. The front doors of most establishments are less exposed to rats and are generally protected with a kick plate. Wooden door jambs can be flashed with sheet metal to protect them from rat gnawing. Because open doors provide ready entry for rodents, both screen doors and wooden doors to food-handling establishments should be equipped with reliable self-closing devices.

Vents and windows can be made secure against rat entry by screening them with heavy wire mesh, preferably in a sheet-metal frame. If desired, fly screening can be incorporated into the frame also. Wooden surfaces exposed to gnawing must be covered by the frame.

Metal guards of suitable construction should be placed around or over wires and pipes to prevent rats from using them to gain entrance into a building.

Openings around pipes or conduits should either be covered with sheet metal patches or filled with concrete or brick and mortar.

The use of concrete for basement floors and for foundations not only prevents rat entry but also increases the value of the property.

Floor drains, transoms, letter drops, and fan openings must receive stoppage consideration.

Materials for ratproofing

1. 17-gauge, 2" x 2" (1/2-inch mesh) galvanized hardware cloth for screening against rats; 19-gauge, 4" x 4" (1/4-inch mesh) for mice.
2. 18-gauge galvanized expanded metal for screening where exposure to damage is greater than normal.
3. 24 to 26-gauge galvanized sheet metal.
4. 1/8-inch brass or aluminum for kick plates.
5. Concrete, brick and mortar, glass, tile, and other building materials.

As an adjunct to vent stoppage, buildings should be planned or modified to avoid dead spaces such as double walls, double floors, and enclosed areas under stairways.

Rubbish piles or other materials stacked against buildings should be removed. They provide the means by which rats and mice can bypass otherwise effective stoppage measures.

After buildings have been completely ratproofed, measures should be taken to eradicate the rodents that have been trapped within.

Inspections should be made at regular intervals to make sure that rats have not been reintroduced in incoming shipments and that the ratproofing work remains intact.

As a general guide in planning prevention measures, assume that rats can do the following:

- Gain entrance through openings larger than 1/2-inch square.
- Climb both horizontal and vertical wires.
- Climb the inside of vertical pipes 1-1/2 to 4 inches in diameter.
- Climb the outside of vertical pipes and conduits with diameters up to 3 inches.

- Climb the outside of vertical pipes and conduits of any size if within 3 inches of a wall.
- Crawl horizontally on any type of pipe or conduit.
- Jump vertically as much as 36 inches from a flat surface.
- Jump horizontally 40 inches if on a flat surface.
- Jump horizontally at least 8 feet from an elevation 15 feet above the finish point.
- Reach about 18 inches horizontally or vertically.
- Drop 50 feet without being killed.

All new buildings should be so designed that they are ratproof. Building codes of communities should be revised, if necessary, to require that new construction be ratproof. Codes should also specify that modifications and repairs be made to existing buildings to render them ratproof.

HOUSE MOUSE

Description

The house mouse is a small, dark gray rodent. When full grown its body is about three inches long and its tail is about the same length. Although young Norway rats are sometimes mistaken for adult mice, the two are easily distinguished. Note that the tail and body of the house mouse are about equal in length, whereas the tail of the Norway rat is definitely shorter than the body. The drawings also show that the grown house mouse is well-proportioned while the young rat, like most baby animals, has a head and feet which seem too large for its body.

Habits and Habitat

An important habit of mice is that of staying close to their supply of food. If they can find a nearby nesting site, they may never travel more than a few feet from their birthplace. This very limited range in their activities is due to their retiring nature and because they do not require as much water as do most animals. They usually obtain all the moisture they need from their food.

Favorite nesting places for mice are in hollow walls, ceiling spaces, under or behind cabinets and similar enclosed spaces. Voids in or between stored materials, particularly sacked feeds, are choice home sites for mice.

Runways are not as easily found as are rat trails. They do, however, tend to follow regular paths along walls. Normally mice travel these paths in short runs from one protected spot to another with a short stop at the end of each run to see if the coast is clear before starting another run. Mice are capable of getting through surprisingly small openings. A baby mouse can go through a hole about one-fourth inch in diameter, while a three-eighth-inch crack, under a door for example, will permit an adult mouse to pass.

Much mouse damage is due to their collecting soft materials for nest lining. They are particularly inclined to chew up paper and to chew holes in furniture upholstering and other forms of cloth materials. Damage to flour and feed sacks may be very great, even though only a few mice are present. However, the greatest potential threat caused by house mice is the spread of disease through contamination of food and feed.

Mouse droppings are much smaller than rat droppings and they tend to be pointed at one end, whereas rat droppings are equally rounded at both ends. When abundant, mice leave a characteristic mousy smell, chiefly from their urine.

RATS VERSUS HOUSE MOUSE

The following is a comparison between the behavior of the house mouse and the general behavior of rats. Once you have identified the rodent, a thorough understanding of its behavior is the next step toward its control. For practical purposes the behavior of the Norway and roof rat is the same except the Norway usually burrows in the soil and the roof rat usually nests above ground.

Territories

Rats are social animals and live in colonies. Several may use the same food and water sources and runways. They even nest close to one another. Rats can be controlled with fewer bait placements since they do share a food source and will travel further for food.

The house mouse is more of a "loner." Each male mouse stakes out a territory. In each territory there are one or more females, food and shelter. The male mouse does not willingly share his territory with another adult male mouse. Mice can be controlled only with many bait placements—at least one in each male's territory—because of these territories and short distances traveled.

Distance Traveled

The rat will travel no further than he has to for food and water. He will travel 100 feet or more if necessary. In urban areas, rats stay on their own block and are usually restricted to smaller areas within the block.

The size of a mouse's territory depends upon the physical arrangement of his environment and the number of other mice in the area. The more mice, the less territory each has. The mouse may not travel more than 10 feet from his nest if food is close by and/or if there are many mice in the area. Some mice may spend their entire lives in a pallet of feed.

Activity Periods

Rats and mice prefer to come out and feed at night and are most active at dusk. If a building is lighted in the evening, activity begins after the lights are turned off. Under continuous lights the rodents will be active during the quietest periods. When living conditions become overcrowded for the rodents, some will be active during the day and your customer will see them. This indicates a very heavy infestation.

Feeding Habits

All rodents feed in accordance with body needs. This is influenced by temperature, amount of free water (water available for drinking) and the amount and kinds of food. Although there are exceptions, we can generalize as follows:

Rats become conditioned to eating a particular food. They approach new food with much suspicion and taste it cautiously. If it tastes bad or makes them sick, they won't eat it again. This is bait shyness.

Once the rat finds a food it likes, it will fill itself in one feeding. When baiting, you can often get effective control by using a bait that is identical to the food the rats are using. If a different food is used as bait, prebaiting with unpoisoned bait for several nights will increase bait acceptance. Rats prefer good quality food so your baits must be as good and preferably better than the rat's regular food. Top quality yellow corn meal and oats make a good "universal" bait, but no bait is best for all situations.

The house mouse is not suspicious of new foods and will eagerly sample them. This habit aids you in baiting for mice. To offset this, however, mice will go back to feeding on other foods if your bait is not as attractive. Also, they nibble. Because they nibble and feed on many different foods in one night, it is difficult to get them to ingest a lethal dose of a poisoned bait. As with rats, there is no "best" bait for all situations. Attractive baits include pineapple, prunes, gumdrops, and peanut butter.

Water Requirements

Rats require free water to drink if feeding on dry foods, such as grain. If you can eliminate their water source, liquid baits are very effective.

House mice can survive long periods without drinking water. If their food contains some water, they don't need any drinking water. Water baits are readily accepted, however, and you may find them more useful than dry baits in some situations.

Reactions to Environment

Rats and mice tend to become very familiar with their environment. The mouse checks out his territory at least once every 24 hours and the rat keeps check on the area around his nest, food, water and between his runways. When changes occur, rats and mice react differently.

Rats are very suspicious of any changes. They approach new objects cautiously and may even avoid them the first few days. Even a change in position of familiar objects causes suspicion. Eventually rats adjust to any change. Therefore, they may avoid your traps and bait boxes the first night or two. Since the weaker rats are usually the first to investigate a change, you will trap or kill the weaker, nonbreeding rats first. If so, all you've done is temporarily reduced the population. Prebaiting or placing unset traps ahead of time will help overcome this reaction. If possible, avoid changing anything else in the rat's environment. Changes of light, noise or other factors may upset the rat and make him very wary.

The house mouse reacts to change by exploring it immediately. He usually nibbles new baits as soon as he finds them. He will investigate traps even though they are unbaited. In fact, your control success may be increased if you make constant changes in the mouse's environment. Changing baits or the placement of baits or traps helps. Although unbaited traps catch mice, baited traps increase your success.

Movements

Rats are less suspicious when first entering a building since everything is new and they must "learn" the new environment rapidly. You can most easily trap or bait them. Perimeter control programs work well because they intercept rats migrating into the area when they are more easily trapped or baited.

Once the rat has explored his new home and settled down, he becomes suspicious of changes and is once again wary of traps and baits. The rat established pathways between nest, food, and water. These pathways are along walls or objects where possible. In continuously lighted areas, the rats will move in the shadows. Traps and baits should be placed along these pathways. Sometimes you can place boxes or other objects to "lead" rats to a trap or bait. Remember, the rat may be suspicious at first.

Mice will explore large areas when moving into an environment. The territories established may be smaller than the area originally explored. To encourage mice to range farther so they will find your traps and baits, their environment should be disrupted as much and as often as practical. Palleted stacks in warehouses should be moved and/or restacked on a regular basis. Every time this is done, the mice will come out of the stacks and re-explore the area. This is the time to control them with traps or baits.

TRAPPING RODENTS

Types of Traps

Many types of traps are used for capturing commensal rodents. Included are common wooden-base snap traps, steel traps, wire live traps and multiple-catch box traps such as the Ketch-All.

Box or cage traps: Cage traps are designed to catch an animal and keep it unharmed until it can be removed for disposal. These traps may either catch one animal at a time or several. In the first case, a sliding door slams down behind an inquisitive rodent when his weight on the balanced floor or his greedy nibbling at a bait triggers the mechanism holding the door open. The multiple-catch trap is usually more intricate. For example, the Kness Ketch-All forcibly shoves a victim into a closed compartment and hurriedly opens its doors to the next prospective customer.

Glues: Sticky chemicals that entangle the victim may seem rather impractical for anything bigger than a fly, but they have been used in India for nothing less than tigers. Rodent glues are undoubtedly more effective for mice than aggressive Norway rats, but they are used for the latter, too. The sticky material is applied to heavy kraft paper, cardboard, roofing paper, etc., and placed in rodent runways. Glues can be purchased commercially.

Glues, however, have very definite limitations. They are messy and become less effective at low temperatures and under extremely dusty conditions. They are most often used in combination with other methods.

Jump or snap traps: This final category includes the traps that are the most useful in commensal rodent control. The steel jump trap, larger versions of which are used to catch many types of animals from muskrats to bear, usually catches an animal by a limb.

However, this type of trap is not necessary in control work and the wood-base guillotine or snap trap are much more practical. The snap trap is cheap, easy to operate, somewhat more versatile to place, requires fewer inspections and, since the animal is killed almost instantly, more humane. For most purposes, this trap is the one recommended for use by the PCO.

Trapping Techniques

Effective trapping of commensal rodents depends on several factors. The most important is an understanding of rodents' basic traits. Norway rats, while as agile as tree squirrels when necessary, are more at home on the ground and will normally be caught there. Roof rats are fond of climbing and can be taken more frequently from their runs along pipes and supporting beams. The habits of mice vary somewhat from the other two types of rodents. They are much more inquisitive and explore their environment continually. It is this drive that causes a mouse to investigate a newly-placed trap, whereas a rat is apt to avoid it because of the well-known "new object reaction." For this reason, rat traps should be permitted to remain in place longer than mouse traps.

Mechanical Condition of Traps

Before setting traps, make certain that they are in good mechanical condition. The time lost because an animal escapes is more expensive than the placement cost of a trap. If oiling is considered necessary, use oils of animal or vegetable origin rather than petroleum, which may have a repellent effect.

Rats and mice are thoroughly familiar with the odor of humans and their furnishings, and since the odor of rats that have been killed in a trap acts as an attractant, trap odors play only a minor role.

Discard older traps that have become rusty. The wooden base should not be warped, otherwise it will rock when the animal steps on it. Triggers should be adjusted so that a light touch will set them off, but not so fine that a passerby may jar them. Do not set the bait pan at an angle high enough for the animal to squeeze under it and jam it further back on the trigger, or so low that there is no place left to spring the catch.

Enlarged Bait Pans

While there is a commercial trap with an enlarged bait pan, most traps are not so equipped. Enlarging the bait pan with a small square of cardboard (not recommended for damp locations or prolonged use), thin metal or wire screen is a simple but very effective device. The enlarged bait pan turns the ordinary trap into a runway trap which when properly set, will be sprung as the animal steps over it, even if he is not attracted by any bait.

Trap Shelters

A thin metal shelter constructed over the trap is another worthwhile modification. The main purpose of the shelter is to force the animal to pass over the bait pan, but it also acts as a drag to prevent loss of the trap and discourage piling of materials directly on it.

Trap Placement

Another important factor in determining success is the placement of the trap. For this reason, the value of "tracking patches" and reading "signs" cannot be overemphasized. Tracking patches are thin layers of flour, loose dirt, talc or other finely divided material that has little or no deterrent effect. The material is spread in one to two foot lengths in areas that animals are likely to frequent. These patches are smoothed over so that fresh tracks can be easily read, even by the untrained eye. This method enables the serviceman to determine what areas are being used by the animals, to estimate their numbers and, at the conclusion of a trapping period, to ascertain if any animals are still on the premises.

In addition to these artificial measures, a good trapper will look for signs left by the animals to show established routes. The body oils and extraneous filth picked up by rodents is laid down in a black line or smear since they normally press close to the wall of familiar route. If roof rats are present, "swing marks" are made as the rats pass under rafters while travelling along a horizontal support. A keen eye can also detect the presence of fresh droppings, hair, and tracks in the dust. All of these signs can be used to determine the best placement of traps.

Place traps where active runs have been discovered. Set traps perpendicular to the run with the bait pan close to the wall or solid surface. If the traps are not enclosed in shelters as described above, it may be necessary to narrow the passageway with boxes or other solid items. This forces the animals to pass over the bait pans.

A common mistake of the novice is to skimp on the number of traps. For mice, with their limited movements in established habitats, one trap for every 2 to 3 square feet is not excessive. It is more efficient to overtrap an area than to undertrap.

However, even with good trapping techniques, some individuals will evade all efforts. It is the catching of these smart ones that taxes the ingenuity of the PCO. With roof rats, traps can be nailed on upright supports or fastened to horizontal pipes.

Traps can be camouflaged with torn strips of facial tissue, oatmeal, cornmeal or sawdust. If fine materials are used, it may be necessary to add miniature trap pads to keep the bait from collecting under the pan and to prevent the trap from springing. Also, putting two or more traps side by side, particularly in a shelter, will surprise even the most evasive rat.

A number of traps should be used. Traps should be placed within 10 feet of each other for controlling mice. Traps should be placed within 20 feet of each other for controlling rats. If rodents seem to be jumping over the traps they should be placed in groups of three or more in a parallel series. On

horizontal pipes or beams, where traps are set in a series, one end should be tied to the pipe or beam. Then, when the trap is snapped, it will bounce off the support and hold the animal suspended in the air clearing the pathway for other victims.

Traps should be placed so they will not endanger pets or children. Ketch-All type traps, wire live traps, and snap traps designed only for mice are not considered dangerous, although they may bruise the fingers of a child. Larger snap traps and steel traps should not be placed in areas accessible to children unless they are placed in trap boxes.

Do not place any trap directly above food or food products or surfaces, equipment, or containers that exposed food will contact.

The number of traps placed on each job should be recorded. In food plants, the location of each trap should be mapped. This will enable someone else to follow up an account if necessary.

Traps should be revisited frequently. Unless the trapped rodents are in concealed places, the traps should be checked as early as possible in the morning to remove the trapped animals. Trapped rodents are a discomforting sight to many people and the rodents can produce odors.

Dead rodents should be carefully removed because of the disease and ecto-parasite hazards. The carcass should be taken off the premises or put in wet garbage where it will soon be removed. Avoid direct contact with dead rodents by using gloves or long forceps.

Intensive trapping for several weeks is recommended. Traps should be left in place for at least five days before moving them to other locations, because there may be some "new object avoidance" when the traps are first encountered.

BAITS AND BAITING

When a trap with an enlarged pan is properly placed, it is not necessary to bait it. However, baiting increases the possibility of success. A light smear of peanut butter or a sprinkling of oats, cornmeal, doughnut or bread crumbs over the pan is sufficient.

When an unmodified trap is used, baiting is essential. Many baits have been recommended, but there seems to be no universal bait that will appeal to all individuals in every environment. The following are a few that have been successful under some condition: raisins, strawberry jam, ground beef, nutmeats, sardines, wieners, Grapenuts, chocolate, apple, carrots, and sweet potatoes. Gumdrops make excellent mouse bait because they are difficult to remove without springing the trap.

Success is reported with bacon rind and cheese if they are attached to the bait pan and then toasted with a match. A semipermanent bait has been made by kneading bacon grease into small clay balls or chewing gum. If a highly attractive food source is already available, cotton for nesting has been very successful at times. The use of nesting material is also effective inside cold storage.

House mice are nibblers and like to try new foods. Therefore, using baits different from the usual food source often works well on mice. NPCA-supported research at Southern Illinois University shows that prunes, pineapples, and the juices of both are favorites of house mice. Water baits are seldom practical.

All bait materials should be fresh. Moldy, rotted, or dried-out baits are poorly accepted by rats and mice. Baits must not taste or smell of other chemicals. If you transport baits in a vehicle with insecticides, keep the baits in airtight containers.

Food baits should be crumb sized or a sloppy paste to reduce the possibility of rodents carrying baits to other areas. All recognizable foods should be diced, rolled or otherwise made unrecognizable.

If you mix your own baits, follow the directions on the USDA registered label for the rodenticide used. Generally, the rodenticide should be mixed with the liquid or moist part of the bait formula first, and this mixture blended with the dry ingredients. Baits should be well mixed so that the toxicant is distributed evenly throughout.

Bait Placement

When practical, baiting should be done in late afternoon. Rats and mice most often look for food at dusk. Baits stand a better chance of being fresh at dusk if placed in late afternoon.

Baits must be placed so that they are not readily accessible to children and other animals. You may have to use bait boxes, but not throw bags, to achieve this in some areas.

Baits should be placed where rodents will find them. Rats usually feed in one place so a relatively few bait stations will often suffice. Baits should be placed under cover, in burrows and along walls. Mice will feed in many places during a night and they will not travel great distances. Many placements are needed, and they should not be more than 10 feet apart when baiting for mice.

The amount of bait needed depends upon the rodent species, the size of the infestation and the toxicant. There should be more than enough bait to feed all rodents present. If all baits are eaten the first night, then not enough bait was put out. Teaspoon-sized placements will suffice for mice and tablespoon-sized placements for rats when the account is serviced daily. Larger amounts are needed when the account is serviced less frequently, especially when anti-coagulants are used.

Prebaiting

Prebaiting is the exposure of unpoisoned bait for several nights prior to using poisoned bait. The bait material must be the same during both periods. Prebaiting should be done for two nights to a week. This will accustom rats to feeding on a certain food at a certain place each night. This overcomes rats' natural reaction of avoiding new foods and bait shyness in rats previously poisoned. Through prebaiting, you can estimate the amount of poisoned bait

needed and where it should be placed.

Prebaiting is useful for controlling "difficult rats with quick-acting rodenticides. Prebaiting is too costly for large-scale or routine use. It is unnecessary when using anticoagulants and is generally not worthwhile for house mouse control

TYPES OF RODENTICIDES

Anticoagulant Rodenticides

The anticoagulant rodenticides, which include Warfarin, Chlorophacin, Fumarin, Pival, Diaphacin and PMP, act by disrupting the normal blood-clotting mechanisms. Although the anticoagulants are considered relatively safe, these rodenticides must still be used in such a manner as to protect the public and domestic animals. They are available both as dry powders, which are to be mixed with solid baits, or as salts, which are to be mixed with water to produce liquid baits. In addition, chlorophacinone and PMP may be used as tracking powders.

Anticoagulants may be used in homes and business establishments with the following precautions:

1. Present all poisoned baits as conveniently and attractively to rodents as is consistent with safety, and in such a manner so as to preclude contamination of food or foodstuffs. Exposure within a building should be at floor level.
2. Where anticoagulant baits are used indoors in areas where the public, children, and domestic animals are present, the bait should be kept in a covered rodent bait station. A warning lable must be affixed to the container. Open bait trays may be used indoors if placed in areas not readily accessible to the public, children, or domestic animals.
3. When baiting outdoors, place all baits in burrows, tunnels, deep holes, or in covered rodent bait stations. If baiting is one when conditions are wet or may become wet, then grain baits coated with anticoagulents and imbedded in paraffin should be used.

4. A sufficient amount of anticoagulant food or water bait should be set out at one station where rodents are accustomed to feeding. Assure an uninterrupted supply of bait for a period of not less than 15 days and continue baiting until all signs of feeding have stopped.

It is essential that these precautions be strictly adhered to because of the functioning of anticoagulant poisons. In normal use, rodents must consume several doses a day over several days before death occurs. For this reason anticoagulant rodenticides are also called multiple-dose poisons.

All dry baits should be inspected at least once per month and replaced with fresh baits if insect infested, moldy, or otherwise unattractive to rodents. Baits should be replenished as necessary to ensure an adequate food supply for rodents.

Insect infestations of cereal type rodent baits containing anticoagulants should be prevented so that bait acceptability remains good and the treated premises do not become insect infested. The probability of insect infestation can be minimized by fumigating the bait, storing it in an insect-tight container prior to use, and removing and destroying exposed baits at least once a month.

Single-Dose Poisons

Antu: Antu is a relatively safe, quick-acting poison which can inexpensively accomplish reduction of Norway rat populations. Antu is not effective against mice or roof rats. It is less effective against the young than the adult Norway rat. Most other animals are not susceptible to Antu, but pigs, cats, dogs, and horses are susceptible. It is not absorbed through the skin. It may be used as a bait or as a tracking powder. Rodents killed with Antu present no secondary poisoning hazard, but should be recovered for sanitary reasons.

Antu should be used no more often than once every six months in or on a premise because rats develop a tolerance and bait shyness to this rodenticide. After initial reduction of a rat population, Antu should be replaced with another rodenticide or method.

Antu can be mixed with any food acceptable to rats such as ground meat, bacon, fish, grain, fruits, or vegetables. When using baits, the following precautions must be followed: (1) Outdoors, baits may be placed in furrows, tunnels, beneath objects, or in protected bait stations. (2) Indoors, baits may be placed in open rodent bait trays if children or pets don't have access to the baited areas.

Antu may be used as a tracking powder. If a concentrate is used, dilute it with talc, flour, or other inert ingredients to prepare a tracing powder.

Arsenic trioxide: Arsenic trioxide is a toxic rodenticide that is effective against Norway rats, roof rats, and mice. Ingestion of sublethal amounts may result in development of a tolerance. It is not absorbed through the skin and there is no secondary poisoning hazard. It should be used as a short-term specific corrective agent and not as a routine maintenance rodenticide.

Because of arsenic trioxide' s toxicity, the following methods and precautions should be adhered to in its use:

1. When arsenic trioxide is dusted onto solid foods, these foods must be diced, rolled or crushed to render them unrecognizable as human foods.
2. Persons preparing or placing baits should wear disposable gloves and wash their hands after any handling operation. They should not smoke or eat until their hands have been washed.
3. When preparing arsenic trioxide baits, a respirator must be worn to prevent inhalation of the dust.
4. PCO's utilizing this agent should collect all unused baits and all bait containers at the completion of the program. Baits should be buried or burned. Bait containers should be burned or buried if they are not to be reused. Reusable containers should be washed to prevent build up of residues. Carcass retrieval is unnecessary for safety but should be considered for good sanitation and public relations.

Phosphorus: Phosphorus is an extremely toxic, quick-acting rodenticide that is effective against both the Norway and the roof rat. Its strong odor is believed to make it unattractive to house mice. Phosphorus possesses one advantage over several of the other more toxic rodenticides, in that it posses a minimal hazard of secondary poisoning. This is a result of the material being oxidized in the stomach of the rat. This rodenticide is not recommended as a routine maintenance rodenticide, but rather as a short-term specific corrective agent.

Because of its extreme toxicity, the following methods and precautions should be adhered to in the use of phosphorus paste:

1. Phosphorus paste may only be used when less hazardous materials cannot be expected to provide adequate control in a given situation. This can only be determined after a careful inspection has been made of property to be treated.
2. Phosphorus paste must never be utilized in any areas accessible to children, poultry, pets, or domesticated animals or used in residences.
3. Phosphorus paste must never be used on a readily recognizable food material such as whole bread slices or cookies. It can be utilized on samll squares of bread cut into maximum sized of 1/2 inch.
4. The final bait form should be formulated only when needed and all personnel handling the paste should wear rubber gloves and be instructed to carefully wash their hands after any handling operation. Personnel should be instructed not to smoke or eat during the performance of any of these activities.
5. Finished baits should not be scattered or broadcast, but carefully placed in burrows, which are then closed, or other places inaccessible or if indicated, in safety rodent bait stations.

Red squill: Red squill is one of the safer rodenticides available, approaching the anticoagulants in safety. The characteristics that make it relatively safe are: a bitter taste which is objectionable to man and many domestic animals; and its strong emetic action which causes prompt vomiting.

Because of its strong taste, red squill is effective against the Norway rat only. Even in the Norway rat, a sublethal dose will cause severe bait shyness; therefore, more bait should be used than is likely to be consumed so that a lethal dose is available to the entire population on the first feeding.

Generally, the most effective use of red squill is for a quick reduction of a rat population over a short period of time. It is not suited for continued use because many of the surviving rats will be bait shy. It is suggested that it not be used more often than every six months against any given rat population. Ground meat or fish are the most attractive baits, but cereals are adequate in most cases. Prebaiting will increase effectiveness.

The following precautions should be observed:

1. Because red squill is irritating to the skin, it is advisable to wear rubber gloves when preparing or handling baits.
2. It may be used with caution in homes, commercial buildings and outdoors.
3. It should always be placed out of reach of children, domestic animals and irresponsible persons. If necessary, covered rodent bait stations should be used.
4. Since red squill does not pose a secondary poisoning hazard, dead rats need only be recovered and disposed of for sanitary reasons.

Sodium fluoroacetate (1080): Sodium fluoroacetate is an extremely toxic rodenticide which must be used with extreme caution. It is tasteless, odorless, water soluble, and usually works very fast. The qualities that make it effective are the same ones that make sodium fluoroacetate hazardous. Because there is no known antidote and there is a secondary poisoning hazard, many special precautions must be followed in order to use this rodenticide safely. Good practice in the use of sodium fluoroacetate requires the public health official to comply with instructions on labels, manuals, and agreements provided by the manufacturer and to give special attention to the precautions listed below. These precautions apply to work done by pest control operators in controlling commensal rodents (Norway rats, roof rats, and house mice).

Sodium fluroacetate may be used only when less hazardous materials cannot be expected to provide adequate control in a given situation. This can be determined only after a careful inspection is made of the property to be treated, and after a thorough evaluation of the rodent infestation as related to the environment and the colony history.

Sodium fluoroacetate is not to be used in or around residences or places inhabited or frequented by children, irresponsible persons and/or pets.

Sodium fluoroacetate may be used in commercial, business and military establishments, including food processing plants and on ships if the precautions below can be followed.

1. All containers of sodium fluoroacetate must be stored in a locked room or cabinet on the PCO's premises. Water solutions of sodium fluoroacetate should be transported to the job site only in unbreakable containers such as rubber or plastic that are properly labeled and the vehicle in which they are carried should be kept locked when unattended. On the job, sodium fluoroacetate containers must be kept within sight of the man using them.

2. Sodium fluoroacetate should be exposed only as a water solution except as noted below. Avoid an increase due to evaporation of water from bait containers.

3. All sodium fluoroacetate water solutions must be colored with an acceptable black dye.

4. Exposure of sodium fluoroacetate solutions within a building should be only at floor level.

5. Sodium fluoroacetate may be exposed in unprotected containers only when the building (or portions of buildings) to be treated is under complete control of the PCO during the entire exposure period so that no person, pet, or domestic animal can enter the treated area.

6. Containers for open exposure of sodium fluoroacetate must be conspicuously labeled, specially designed cups, glass coasters, or other containers that will not permit seepage for a period of three days. Such containers must have a flat base and their diameter must be at least three times their height. The containers must be designed so that they cannot be readily carried or

overturned by commensal rodents.

7. Bait boxes for protected exposure of sodium fluoroacetate water solutions must be sturdily built and locked or otherwise securely closed so that the rodenticide is not accessible to humans, pets, or domestic animals. They must be designed so as to prevent ready access to the poison by pets and persons other than the operator. These boxes must be capable of preventing leakage, or equipped for absorbing any sodium fluoroacetate solution spilled within them. These boxes must bear a label with the words "Sodium Fluoroacetate-Poison," and a skull and crossbones. Dispensers for use in the bait boxes can be of different proportions than those given above if designed so that their contents will not spill out if knocked over.

8. Sodium fluoroacetate may be exposed in buildings not under PCO's complete control only if placed in safety rodent bait stations securely fastened to the floor or ground and all personnel in the area are notified of the use of sodium fluoroacetate and its hazards. It is desirable to have an official who is responsible for all personnel in the area sign a statement that all such personnel have been notified of the use and hazard of sodium fluoroacetate.

9. When solutions are exposed continuously, old solutions should be removed, the containers cleaned, and fresh solutions added at each servicing. Otherwise, the concentration may become excessive due to evaporation.

10. For each exposure of sodium fluoroacetate solution, a diagram of the property should be made and each solution located thereon at a numbered location. A copy of the diagram should be left with a person responsible for the treated property.

11. At the close of operations, all unused water solutions and containers must be recovered and a diligent search shall be made for all poisoned animals. When solutions are exposed continuously, all poisoned animals must be picked up daily by the operator or by a person responsible to the owner of the treated property and who

has been instructed by the PCO regarding the hazards of sodium fluoroacetate. Personnel should be instructed to wear rubber gloves during these operations, to carefully wash their hands afterwards, and not to smoke or eat before washing.

12. All unused sodium fluoroacetate solutions and all disposable solution containers and poisoned animals must be properly disposed of—preferably by incineration, or by burying at least three feet below the surface of the soil in an isolated location. In large cities, solutions, containers, and dead animals should be taken to the appropriate city facility and the operator should see to it that they are incinerated or properly buried. They should not be dumped into sewers or placed in refuse containers to be picked up by regular garbage disposal teams. The responsibility for disposal of carcasses may be delegated to others when sodium fluoroacetate is exposed continuously. Water solutions of sodium fluoroacetate should be scattered on large amounts of absorbent paper (such as newspaper) before being incinerated. Glass or other durable containers for individual placements may be washed and reused but they must be identified for this use only.

Records of each use of sodium fluoroacetate water solutions should be maintained for at least a year. Records must show: (1) date of exposure, (2) address and description of exposure site, (3) diagram of placements, (4) an explanation of any difference between the number of baits exposed and recovered, (5) name and address of the person or persons responsible for the exposure of baits and the recovery of baits and dead animals.

Sodium fluoroacetate may be exposed in a food bait (nonwater) in concentrations not to exceed the manufacturer's recommendations in dumps and burrows if the following contions are met:

- All precautions as used for sodium fluoroacetate water solutions must be followed except it is unnecessary to use a bait container.
- The bait base shall be of a dry crumbly particulate type or a thin paste so that the bait cannot be readily carried to other areas by rodents.

- The sodium fluoroacetate must be thoroughly mixed with the bait. The toxicant may be dissolved in a small amount of water or blended in a dry form with a small amount of one of the bait ingredients to facilitate mixing.

- The bait shall be placed in such a manner so that it will not readily be accessible to birds, desirable animals, or the public. When placed in burrows, the bait should be put far enough into the burrow so that domestic animals cannot reach it readily. Bait applied to dumps should be placed beneath objects, in containers, or into holes so that it is inaccessible.

- Appropriate warning cards must be conspicuously displayed in adequate numbers whenever sodium fluoroacetate baits are used on public property or on private property readily accessible to the public. There is no need to post private property not readily accessible to the public.

- If baits are placed in burrows or in accessible spots on dumps, there is no need to retrieve them. Retrievable baits which constitute a hazard must be destroyed. If a dump is to be burned or filled, it is desirable to bait a day or two prior to this so that hazard from remaining baits and dead rodents is further reduced.

  Maintain a record of each bait application for at least a year. The record should show the application date and the address and description of the application site.

Strychnine: Strychnine is an odorless, colorless crystalline material with an extremely bitter taste. It is very fast acting and extremely toxic. There is a well-documented secondary hazard to dogs, cats and wild carnivores.

Strychnine is most often used for the control of house mice. It is not effective in rat control because it is too rapid in effect. Individual rats will reject the poison and populations will become bait shy.

Strychnine normally should be used only on grain baits to minimize hazards to dogs and carnivorous wildlife. Exceptions can be made in the control of certain native rodents, for example, porcupines.

This rodenticide is for use as a short-term, single-dose corrective agent. Strychnine on wheat, hulled seeds, steam-crushed oats, or cracked corn may be used for house mouse control on a limited temporary basis. It should never form the backbone of a control program for house mice. It normally should be used after a good sanitation clean up. Good grade anticoagulant baits should precede a sanitation clean up. This allows the strychnine to be most effective against displaced or disrupted remnant populations.

Strychnine treated baits may also be used to control chipmunks and ground squirrels. Teaspoon quantities of the grain bait should be placed inside all burrows that can be located. If burrows cannot be located, treated bait may be broadcast around the area where damage is occurring, but this technique must be used with care to avoid killing nontarget species.

Mixing strychnine baits requires skill, care and experience. It is recommended that those lacking these requirements purchase supplies from established sources.

When placing strychnine baits in structures:

1. Placement should be governed by the purpose of the structure and the activity of the people therein. Strychnine baits must not be used where there is any likelihood that children can reach them. They should not be used where they might contaminate food, milk, feed stuffs, cosmetics, drugs or other items for human or animal consumption. They can be used in wall voids, or in safety rodent bait stations in nonproduction areas of food plants or warehouses for house mice, IF, safer materials will not suffice for the immediate needs. Placement should always be at floor level.
2. Bait trays or bait stations should always be marked with skull and crossbones and the word poison. It is desirable to notify the building manager or plant operator that strychnine is to be used on the premises.
3. Bait placements should be mapped or annotated in records as to location.

Zinc phosphids: Zinc phosphide is a toxic rodenticide which, when properly utilized is effective against rats and mice. It is a dark gray powder that is relatively insoluble in water and alcohol. In the presence of moisture and/or dilute acids, it releases phosphine gas, which is very toxic and accounts for the garliclike odor of the compound. It is stable for long periods of time under most conditions. It presents secondary poisoning hazards.

Because of its toxicity to all forms of animal life, the following methods and precautions should be adhered to in the use of zinc phosphide:

1. This rodenticide is not recommended as a routine maintenance rodenticide, but rather as a short-term, single-dose, corrective agent.
2. Zinc phosphide should not be used in a manner in which it is readily accessible to children, poultry, pets or domesticated animals. It may be necessary to utilize safety rodent bait stations to accomplish this in some situations.
3. Zinc phosphide should never be utilized on a readily recognizable food material in a form attractive to humans.
4. Zince phosphide can be dusted onto wet baits such as meats or cubed fresh fruits and vegetables as long as they are made unrecognizable as food.
5. When applied to dry baits such as grains, it is recommended that it be carried as a suspension in corn oil or warm bacon grease.
6. When preparing zinc phosphide baits, operations should occur outdoors or in a room with positive ventilation. A respirator should be worn when mixing baits to prevent inhalation of the powder. If very large batches are being produced it is necessary to wear a gas mask approved for phosphine.

BIRD PESTS

Sparrow

The English sparrow, which is also known as the house sparrow, is an imported bird. It does not belong to the sparrow family at all, but to the Old World weaver finches. The birds were introduced about one hundred years ago and have spread throughout most of the United States and Canada. They resemble the true sparrows in size and in their more-or-less grayish-brown coloring. The male has a black throat with white cheeks. They spend much of their time feeding on the ground, and hop but never walk. English sparrows are prolific breeders as they average about three broods per season with four to seven offspring per brood. It is characteristic of this species that both individuals and flocks operate within rather confined areas. Some may move to central areas such as cities in the winter time and disperse to the country in the spring, but as a rule, the feeding, nesting and other activities of these birds occur in a much more limited area. English sparrows compete with many birds preferred for their song or beauty. Being pugnacious, they drive the more desirable birds from nesting sites as well as from feeding grounds. Their nests are relatively large, and are not only unsightly but often plug drains, gutters and the like and thereby cause serious damage from overflowing water. In some cases, each pair of birds makes a separate nest, but in other cases, community nests are used by several families.

In addition, their droppings may cause deterioration of equipment and the contamination of stored feeds, as well as creating an unhealthy and unsightly mess. At times their incessant chattering can be very distracting to some people.

The food of English sparrows is primarily seeds, but they may eat fruit, buds and emerging plants. Occasionally they eat insects but without great benefit to agriculture.

Starling

Starlings also were introduced from Europe. Since their introduction in 1890 in New York, they have spread to the Pacific Coast and even to Alaska. They are dark-colored, chunky, short-tailed birds and intermediate in size between sparrows and pigeons. From a distance they appear to be entirely black but they are actually flecked with light colors and much of their dark feathers show iridescent purples and greens. During spring and summer, their moderately long bills are bright yellow. Some people confuse starlings with blackbirds, but none of the blackbirds has the short tail or yellow bill. Starlings, unlike English sparrows and pigeons, almost always feed a relatively great distance from their roosting places. They are important predators upon many soil dwelling insects, but will eat seeds and grain and occasionally destroy fruits.

There is ample evidence to indicate that some starlings migrate and that others do not. In the spring when the nesting season begins, the birds scatter to suburban and rural areas. They make rather coarse nests in tree holes, bird houses and the like. One egg a day is laid until an average of six or seven eggs have been deposited. Most starlings have two broods per year.

Starlings are objectionable primarily because of their habit of roosting together in large numbers on or near buildings.

These roosts are often objectionable because the large accumulation of droppings may result in deterioration of equipment, contamination of food or feed, and the creation of an unsightly and unhealthy mess.

In addition the noise of these roosts can be considerable and be very distracting to certain people.

Since starling control is largely limited to preventing the birds from using certain trees and buildings as roosts, it is necessary to understand starling roosting behavior. Flocks to be controlled should be observed and their movements recorded. Typically, the roosting behavior of starlings is as follows. During the starling season when the mated birds are dispersed and caring for their young, a few "bachelor" birds travel together between their roosts and feeding grounds. As the young birds of the first brood learn to shift for themselves they join the "bachelor" birds. Later the second brood young and the parent birds join these roosting flocks. The great increase in the size of the starling flocks about midsummer indicates that the parents and their second brood of offspring have joined the roosts. From then until late in the fall, starlings use the summer roosts which are often in trees. It appears that deciduous trees such as the Norway maple are well suited for starlings in the summer.

Migration may occur when the birds leave their summer roosts. Those that remain in an area usually shift their roosts to city buildings which they use throughout the winter.

In their daily cycle of movement, starlings leave their roosts rapidly about sunrise. They fly in flocks over fairly well-established flight lines and for distances up to 50 or even 70 miles. In the evening, those farthest from the roosts are the first to turn back so that all reach the general vicinity of the roost at approximately the same time. The time for entering and leaving roosts apparently is controlled by light intensity.

Pigeons

The common pigeon is not native to the United States, but was imported as a domestic bird and is still raised in captivity today. The wild flocks that exist throughout the United States today are the offspring of escaped domestic birds. The normal color pattern for wild pigeons is a blue-gray body with iridescent feathers about the neck and lighter gray wings with dark gray stripes in the wing feathers. Recent escapees joining the wild flock may introduce whites and browns into the population but normally after many generations of wild living these colors disappear from the flock. However, escapees are continually joining the wild flocks and so at any time a flock of pigeons may contain individuals with wide variety of color patterns consisting of blues, grays, whites and browns.

In their native habitat around the Mediterranean the common pigeon nests on cliffs. In the United States, pigeons have adapted and roost and nest on man-made structures such as buildings, bridges, homes and barns. Pigeons use these structures for nesting, roosting at night, and as resting spots during the day. Normally they feed on sources of food nearby such as city streets and parks, yards, railroad yards, dumps, ballparks, drive-in movies, and drive-in restaurants. Occasionally, however, they may fly many miles to feed in agricultural areas such as grain fields or livestock feedlots.

Pigeons normally begin nesting in the spring and may nest three or four times during the spring and summer, producing two young per nest. Their eggs are white and approximately one-half the size of a chicken egg. However, if pigeons can gain access to the inside of a structure they may nest year around and it is not uncommon to find eggs or young in a nest in January. Pigeons will nest anywhere they can find a convenient, flat surface that offers some protection. Thus, nests may be found in rain gutters, ledges, windowsills, cornices, atop columns or doorsills, or in the inside of structures such as belfrys, clock towers, attics, warehouses, etc. Their nests have been found in such unlikely places as sink basins, commodes, nonfunctioning clockworks, and the pigeon holes of an abandoned post office. Although pigeons usually make nests of twigs, they will frequently nest in accumulated droppings.

The presence of pigeons may create problems in that their nesting material can clog rain gutters and their droppings may cause a deterioration of structures and equipment, contaminate food and feed, and create an unhealthy mess. In extreme situations, droppings may accumulate to the point where their added weight can threaten structural stability, especially if the droppings become wet. Pigeons may also transmit diseases that affect humans and domestic animals.

BIRD-BAITS

Bait Selection

Using the proper bait will have as much bearing on your results as will the choice of avicide and bait placement. You should consider the following when choosing bait.

Species of Bird

Because of difference in size, different birds consume different sizes of bait particles. The following helps illustrate choices of size: pigeons—whole kernel corn or poultry pellets; starlings—medium cracked corn or poultry crumbles; sparrows—finely cracked corn or poultry starter.

Food Habits of the Bird

Birds have poorly developed senses of taste and smell. Thus, in selecting and choosing foods, they rely heavily on previous experience, familiarity with the food, and the sense of sight. Therefore, birds tend to reject new and different food. Consequently, the best bait is a food which the birds are accustomed to consuming. For example, if starlings are accustomed to feeding on food scraps at a dump, cracked corn is a poor bait selection. Conversely, if starlings are accustomed to feeding on cracked corn in and around a mill, food scraps may not be readily accepted.

Obviously food bait should be as fresh as possible. Dispose of any moldy, rotted or stale bait.

Bait Placement

Just as familiarity with a food is important to birds in their selection of foods, so is the location of that food. Consequently, birds prefer to feed at a selected spot because they have fed there before and know from experience that it is safe. Hence, it becomes very difficult to induce birds to select food at an area where they are not already accustomed to feeding. Therefore, wherever poison baits are used, placement should be on a site where the birds are accustomed to feeding—if safe and practical.

When exposed, bait should be placed in as natural a manner as possible. Whenever trays or pans are used to contain bait, a new dimension is added which makes the birds wary. Further, the deeper and narrower the container, the less likely birds will feed from it. Bait should not be distributed in piles but scattered as widely as possible. Because birds are often aggressive towards one another, especially males of the same species, piled bait permits fewer birds to feed at a given time than a bait widely scattered.

Birds feed most actively just after dawn and just before sunset. Thus, bait placement is best done just at dawn or, if necessary, at night so that the food is available for the birds early in the morning. In general placement should occur when birds are least likely to see the placement actually occurring and if prebaiting is conducted, placement of the poison bait should be done in exactly the same manner by the same person at the same time as the prebait was distributed.

If you mix your own baits follow the directions on the EPA registered label for the avicide used. Baits should be well mixed so the toxicant is distributed evenly on all particles.

One final consideration to make in bait placement is whether the birds feed in an area or if they can be induced to feed in the area? If the birds already feed in the area then much of the problem is overcome. If they do not, prebaiting becomes a necessity. However, it is necessary to judge whether the bird is ever likely to feed in the area. For example, if birds use a structure simply as a night roost, then control of the roost by poison bait is unlikely for the following reason: birds arrive at their roost just prior to or at sunset and leave just prior to or at dawn. Thus, because they do not feed in

the vicinity of the roost, they are highly unlikely to be attracted to any food placed near the roost. Please note, however, that if the birds use this roost as a resting area during the day, poison bait may be successful.

Prebaiting

Because birds are quick to notice any slight difference in their environment and thus be frightened and be wary of it, prebaiting to get the birds accustomed to feeding on a bait which will be poisoned is usually desirable. However, prebaiting becomes essential when: (1) it is necessary to use a type of food for bait with which the birds are not familiar or accustomed, (2) the bait must be placed in a trough or pan or in some other location at which the birds are unaccustomed to feeding, or (3) fast acting poison is going to be used.

The reasons for 1 and 2 should by now be obvious, but 3 deserves additional explanation. Birds are very sensitive to the behavior of other birds. Thus when you are using a fast-acting poison, it is essential that all the birds of the flock that are to be eliminated consume some of the poison bait before any single birds start to react. If a fast-acting poisonous bait is exposed without prebaiting, a few of the bolder birds within the flock will drop down to feed. Usually, then, they will show symptoms of distress before the rest of the flock joins them, and no further feeding occurs by any birds. Conversely, if a flock of birds has been prebaited and is accustomed to feeding at a given place, at a given time, on a given food, then the entire flock is more likely to descend on the food and consume it enmass.

When prebaiting, the person distributing the prebait should do it in the same manner, same place, the same time, and preferably wearing the same or similar clothes and driving the same vehicle. The greater the deviation from a set pattern, the less likely the chances for success. Prebaiting should be done so that there is an uninterrupted supply of bait provided for the birds for as long as it takes for the birds to feed boldly and eagerly at the site. The prebaiting period should also be used to make sure that no nontarget birds

or other wildlife will be killed by the poisoning operation. Obviously if nontarget species feed on the prebait, they will also consume the poison bait.

Note that a degree of selectivity can be achieved by choosing the proper bait. For example, note that the whole kernel corn when used as a bait will greatly reduce the hazard to small sparrowlike birds, providing, of course, that there are not kernel fragments in the whole kernel corn. Or, as another example, the use of meat scraps or bread as a bait may reduce the hazard to seed-eating birds.

Note that the careful selection of a bait site can also be used to achieve some degree of selectivity. For example, the baiting of sparrows inside a structure poses a hazard to no other birds. Sometimes the baiting of flat rooftops for pigeons can be used to reduce the hazard to nontarget birds.

Types of Avicides

In choosing the proper toxicant, you must consider whether the material has a secondary poisoning hazard, whether it is fast-acting or slow-acting, how it will be ingested, and exactly what the desired results should be.

Amino-pyridine: Amino-pyridine is a moderately fast-acting poison that is toxic to all warm-blooded animals and has low secondary hazard. It may be used as a lethal poison in order to destroy all members of a population, or it may be used as a frightening chemical that repels the population with minimum mortality. The situation and species of bird involved determine which objective is chosen, and the objective is achieved by varying the concentration of the poison on the treated bait particles and by the amount that the treated bait is diluted with untreated bait.

For example, sparrows are not easily frightened from roosting and nesting sites and thus amino pyridine should be used as a lethal agent (i.e., extensive prebaiting followed by placement of undiluted, treated bait). Conversely, if it is desired to repel pigeons from one building with minimum mortality, then amino pyridine should be used strictly as a frightening agent because affected birds display wild, erratic behavior that so frightens the remaining members of the flock that they leave the area and do not return. If the first attempt is not successful, prebaiting and retreatment become necessary. Once an operation

is successful, however, retreatment may not be necessary for several months, or in some cases, even as long as a year or more. It is even possible to mildly affect birds without causing death, but normally once symptoms appear, death follows within 10 to 20 minutes.

Endrin: Endrin is a long-lasting, fast-acting chemical that is extremely toxic to most living organisms. It is toxic both orally and dermally and thus must be used with extreme care. The liquid is placed in a wick-type perch that is attached to roosting surfaces on buildings where there is no possibility of the endrin coming into contact with people, pets and nontarget species. It may not be used in food, storage processing or handling operations.

Fenthion: Although not as toxic as endrin, the same precautions and methods of use also apply to fenthion. See endrin use and limitations.

Strychnine: Strychnine is an odorless, colorless crystal material with an extremely bitter taste. It is very fast-acting and extremely toxic. It poses a secondary hazard to any animal eating the poisoned bird. Strychnine baits are used to control house sparrows and pigeons. Because it is a fast-acting poison, extensive prebaiting is necessary. In addition, if retreatment is necessary, it must be preceded by prebaiting. Although it is important to place strychnine baits in locations where the birds are accustomed to feeding, it should not be placed where there is any possibility of it contaminating items for human or animal consumption or where it is accessible to children or pets. Bait stations or bait trays should be marked with a skull and crossbones and the word poison. Bait locations should be mapped or recorded.

TRAPPING BIRDS

There is a wide variety of traps for catching birds, but the two most successful are traps that contain one-way wire bob doors or confusion entrances. The most practical of these types of traps are the large varieties in which food, shelter and water can be provided so that the traps need not be tended constantly. However, these traps are usually most effective if they are tended at least every other day. Although steel-jaw traps and body-gripping traps can be used for pigeons, their use is usually impractical.

In order for trapping to be effective and efficient, the trap sites must be on places where the birds are accustomed to feeding or where they can readily be attracted by prebaiting. If prebaiting is necessary, it should be done without the presence of the trap. Once the birds begin feeding in an area the trap should be placed in that area and left in such a manner that the birds have easy access in and out of the trap. For example, confusion entrance traps may be turned upside down or one-way door traps may be wired open. The open traps should be baited so that the birds get used to going in and out of the trap to obtain food. Once this occurs, the traps can be set and baited and most of the birds captured in a short period of time.

The preceding technique can be simplified by allowing the birds to become accustomed to the presence of the trap before baiting and setting it. This simplified method is not as effective. Because these live traps will occasionally catch nontarget species, it is important that they be tended regularly so that the nontarget species can be released unharmed. Target species can be removed from the trap and destroyed by asphyxiation.

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Michigan State University Printing

SELF HELP QUESTIONS ON VERTEBRATE PESTS

Now that you have studied the section, answer these questions. Write the answers with pencil without referring back to the text. When you are satisfied with your written answers, see if you are correct by checking them in the text. Erase your answer and write in the correct answer if your first answer is wrong.

1. Where do bats roost?

2. Why are bats objectionable to man?

3. How are bats controlled?

4. What diseases are carried by rats?

5. What signs do rats leave that indicates their presence?

6. How often should garbage be covered with dirt at a sanitary landfill to control rats?

7. How small an opening will permit the enterance of a rat into a building?

8. How can mice be identified from rats?

9. Do mice fill themselves at one feeding or nibble on several foods?

10. What types of traps can be used for rat or mouse control?

11. What are some materials used to bait rats and mice?

12. How do anticoagulant rodenticides kill rats and mice?

13. Should 1080 (sodium fluoroacetate) be used if less hazardous rodenticide will provide adequate control?

14. What are the three most common pest birds?

15. Where should baits for birds be placed?

16. How is endrin applied to control birds?